171884

00009

EXECUTIVE SUMMARY

The September 29, 1990, Record of Decision (ROD) for the Kummer Sanitary Landfill site selects Alternative 3 as the remedy for the ground water operable unit. Alternative 3 employs five wells located on the downgradient (eastern) edge of the landfill property which are intended to capture all contaminated ground water beneath the landfill. A portion of the existing plume is not captured by the system and will eventually discharge to Lake Bemidji. The extraction well effluent would be treated by advanced oxidation procedure (AOP) to remove the organic contaminants and may also be treated for inorganic contaminant removal. Following treatment, the ground water would discharged to a pond near the landfill for reinfiltration.

The ROD establishes a remediation goal of achieving ground water restoration to Maximum Contaminant Levels (MCLs). The ROD states that Alternative 3 is expected to achieve that goal after ten years of remediation.

A critique of Alternative 3 produced four major concerns which detract from the desirability of that alternative. The first is that ground water extraction remedies such as Alternative 3 have been the subject of recent research which indicates the technology is generally ineffective for restoring aquifers to health-based levels such as MCLs. A literature review on the topic is contained in the report. The literature contains publications by environmental professionals which accurately document the physical and chemical processes responsible for the observed long-term sustaining of ground water concentrations at levels above ARARs for sites with active pump and treat remediation. The contributing processes include effects of continuing sources, dissolution, low hydraulic conductivity, adsorption and stagnation. Authors with knowledge of these processes have concluded that aquifer restoration to health-based levels is not feasible, or is possible only through indefinite remediation with associated exorbitant cost. The EPA has similarly concluded that aquifer restoration to health-based ARARs often may not be feasible. EPA personnel have indicated that such aquifer restoration may not be the required goal where site-specific circumstances render such restoration impracticable.

The Kummer Sanitary Landfill site characteristics do not indicate that restoration to MCLs is any more feasible than restoration at other sites which were the subject of the referenced literature review studies. The processes which cause very long-term levels of contaminants in an extraction system may all be expected to exist, to varying degrees, at the site. The literature review indicates aquifer restoration, if possible at all, requires much more time than the 10 year period stated in the ROD. The longer period of operation in turn produces higher present value costs for annual O & M costs associated with the extraction system.

The second major concern regarding Alternative 3 is its containment reliability and effectiveness. The remedy design is based on computer modeling. The modeling work was reviewed and an independent modeling study was performed. The results indicate that the Alternative 3 design may not capture all of the contaminants leaving the landfill. A higher pumping rate may be required to achieve total containment. Any increase in discharge has associated increases in treatment costs.

The third major concern is that the Alternative 3 inorganic treatment process would produce a sludge which may be hazardous. This process is not desirable since it is simply transfer of contaminants between media -- from ground water to sludge. Also, if hazardous, sludge handling, transportation, and disposal present significant chances for future human health or environmental impact. Reduction of any such impacts is a threshold criterion for any remedy.

The fourth and final major concern is the cost of Alternative 3. Alternative 3 is expected to cost between 3.3 and 6.2 million dollars based on present worth calculations for a 30-year period. These cost estimates are likely inaccurately low. The estimates do not include the additional costs associated with the problems identified above (i.e. indefinite pumping and higher discharge rates). Further, these costs were calculated using an unrealistic discount rate of ten percent. If a more reasonable discount rate of four percent is assumed, the Alternative 3 costs are 5.4 to 10.8 million dollars.

In light of the high costs and questionable effectiveness associated with Alternative 3, the viability of other alternatives was investigated. An evaluation of the health risks posed by site conditions indicated that existing or potential ground water exposure is the primary risk associated with the site. Discharge of contaminated ground water to Lake Bemidji also poses risk, but that discharge is expected to occur at levels below established health-based surface water criteria. The risks associated with ground water exposure could be eliminated through the use of institutional controls. Those controls involve the establishment of a well advisory area under Minnesota Department of Health authority and mandatory connection to the municipal supply system under local authority.

Since ROD publication in September 1990, the local governmental units have indicated that the institutional controls could successfully be implemented, thus preventing all ground water exposure. Also, at a public meeting held on August 26, 1991, the community indicated acceptance of, and a preference for, the no-action (i.e., plume monitoring and institutional control) alternative. These two events make the plume monitoring alternative viable for the site since the ROD screened the plume monitoring alternative based on inability to protect human health and expected absence of community acceptance.

A new alternative was developed which involves innovative bioremediation technology. This new approach has been implemented at other sites and will be effective to reduce the organic contaminants at the Kummer Landfill site, to MCL levels. The proposed alternative utilizes air sparging points and a soil vapor extraction system. The bioremediation nutrients, if required, would be introduced through the sparging points. This alternative proposes a two-year implementation schedule which incorporates laboratory and field testing to ensure success. The present worth costs associated with the alternative are 1.3 and 2.2 million dollars based on a ten and four percent discount rate, respectively.

Given the viability of the plume monitoring and bioremediation alternatives, these alternatives were compared with Alternative 3 in a reevaluation of the remedy selection process required by the National Contingency Plan (NCP). In this process, the alternatives are compared based on nine evaluation criteria set forth in the NCP. Then, an alternative is selected based on its ability to meet the overall objective of protecting human health and the environment in a reliable and cost effective manner. The reevaluation of alternatives and remedy selection concludes that the plume monitoring alternative is most preferable, followed by the bioremediation alternative and then Alternative 3.

There are several reasons why the selected alternative differs from the ROD remedy (Alternative 3). First, and most importantly, all three alternatives were determined to adequately protect human health and the environment and to eventually attain aquifer restoration to MCLs. The ROD had screened out the plume monitoring alternative based on this requirement, as mentioned above. The key development that occurred since ROD publication is that institutional controls can be effectively implemented.

A second major reason the ROD remedy was not selected here is that it offers little advantage over plume monitoring, and likely no advantage over bioremediation, yet has exorbitant cost. The ROD stated that Alternative 3 would restore the aquifer in ten years. That would be a significant positive attribute of Alternative 3 but it certainly will not occur. The actual restoration period will be on the order of several decades or even centuries based on the scientific literature and the site characteristics.

Other reasons why Alternative 3 was not selected here include the potential generation of hazardous sludge and the community acceptance of no-action.

A final, and very important factor for remedy selection is cost effectiveness. The relative effectiveness of the selected alternative must be proportional to its cost. As compared to plume monitoring and bioremediation, Alternative 3 does not offer effectiveness proportional to its cost. The major reasons are that it will not restore the aquifer in a short time frame and that it does not contain the entire plume, thus relying as well on institutional controls for health protection. Yet it costs at least two million dollars more than the other remedies. Therefore, Alternative 3 is not the most cost effective.

Between plume monitoring and bioremediation, bioremediation is less cost effective. Bioremediation will act to reduce contaminant mass to MCLs in the entire aquifer. The time frame for restoration will be decades because this alternative, as well as Alternative 3, cannot shorten the duration of contaminant release from the landfill. The plume monitoring alternative will require a longer period of time for restoration, but is protective of human health in the interim. That longer period of time may not be significant compared to the duration of landfill source behavior. Therefore, plume monitoring is considered more cost effective since it costs approximately one million dollars less than bioremediation.

TECHNICAL RESPONSE AND EVALUATION

OPERABLE UNIT 3

REMEDIATION OF GROUND WATER

KUMMER SANITARY LANDFILL

BEMIDJI, MINNESOTA

DELTA NO. 10-91-123

Prepared by:

Delta Environmental Consultants, Inc.
3900 Northwoods Drive, Suite 200
St. Paul, MN 55112
(612) 486-8022

August 30, 1991

TABLE OF CONTENTS

Table of Contents (continued)
Page 2

List of Tables

List of Figures

List of Appendices

TECHNICAL RESPONSE AND EVALUATION

OPERABLE UNIT 3
REMEDIATION OF GROUND WATER
KUMMER SANITARY LANDFILL
BEMIDJI, MINNESOTA
DELTA NO. 10-91-123

1.0 INTRODUCTION

Delta Environmental Consultants, Inc. (Delta), was requested by the city of Bemidji on August 9, 1991, to provide comments and recommendations addressing the U.S. Environmental Protection Agency's (EPA) selected remedy for operable unit three (OU3) remediation of ground water at the Kummer Sanitary Landfill located in Northern Township, Minnesota. Refer to Section II of the "Response of City of Bemidji" for a complete discussion on the site history and background.

Delta's scope of work included the following:

- Review Minnesota Pollution Control Agency (MPCA) files, including the Remedial Investigation Final Report (RI) and the Feasibility Study (FS) generated by MP, Inc. (MP), and the Record of Decision (ROD).
- Evaluate pump and treat technology with advanced oxidation procedure (AOP) for remediation of the contaminated ground water.
- Review health risk analyses conducted to date. Evaluate the health risk analysis associated with the selected alternative compared to the risks that are present today; the landfill cap is complete (October 1991), connection of businesses to municipal water supply, and the area downgradient of the site is now under a Minnesota Department of Health (MDH) Well Advisory.
- Evaluate plume monitoring as an alternate remedial action.
- Evaluate the applicability of in-situ bioremediation of ground water without the removal of ground water or contaminant transfer from one media to another.
- Reevaluate the FS and new alternatives with respect to implications for remedy selection under the NCP.

2.0 SITE BACKGROUND

There have been three OUs identified by the EPA for site remediation. The OUs include:

- OU1 - Connection of Northern Township businesses and residences to the Bemidji drinking water supply.
- OU2 - Source control of contaminated ground water emanating from the landfill.
- OU3 - Remediation of the ground water through the use of pump and treat, AOP treatment and discharge to an on-site infiltration pond.

2.1 Operable Unit 1

OU1 provided an extension of the city of Bemidji municipal water supply system into the affected area. The municipal water supply provides residents with a safe and dependable source of potable water. Currently, all residences have been supplied safe drinking water, except five residences that have refused to hook up (legal action is being brought against the residences to ensure they hook up to the city water supply). In addition, the MDH has issued a water well advisory which prohibits the use of the aquifer for drinking water and other uses. The ground water may be used, if the well is sampled and the results indicate the ground water is safe. OU1 has removed any human health risks to affected residences located downgradient of the landfill.

2.2 Operable Unit 2

A low permeability cap is currently being placed over the landfill. The purpose of the cap is to minimize the leaching of additional contaminants into the ground water as well as to limit direct human contact with the waste. OU2 when completed (Fall 1991) will remove human health risks associated with direct contact with the landfill materials.

2.3 Operable Unit 3

The remedial objectives for the ground water operable unit are stated in the FS conducted by MP. The first is to provide safe drinking water for residents downgradient of the landfill. The criterion for this objective is that residents receive water that is consistent in quality with Safe Drinking Water Act Maximum

Contaminant Levels (MCLs). The second objective is to prevent significant impacts on surface water quality in Lake Bemidji. The criteria for this objective are the proposed surface water quality standards developed by the MPCA Water Quality Division for Lake Bemidji.

OU1 and OU2 provide overall protection of human health and the environment and to meet the first remedial action objective of providing a safe drinking water supply for residents downgradient of the landfill. The alternative water supply will achieve the objective of providing water to residents that is in compliance with Safe Drinking Water Act MCLs.

The second objective is to prevent significant impacts on surface water quality in Lake Bemidji. Ground water and contaminant transport modeling conducted by the MPCA suggests that this goal can be met by the limited further action alternative in conjunction with the low permeability cap for OU2. The modeling concluded that, under a capping and plume monitoring scenario, the volatile organic compound (VOC) plume would first reach Lake Bemidji after 34 years and that the total concentration of VOCs entering the lake at that time would not exceed 5 milligrams per liter (mg/L). These predicted VOC concentrations are below the individual VOC surface water quality standards set by the MPCA Water Quality Division for the lake. After 80 years, the VOC concentrations in the ground water discharging to the lake are predicted to be near the compound detection limits and the total VOC concentration is predicted to not exceed 5 mg/L. The modeling suggests, therefore, that the second remedial objective can be met by a plume monitoring alternative.

The OU3 feasibility study for the site considered the following three remedial actions:

- Alternative 1 - no or limited further action (monitoring and institutional controls).
- Alternative 2 - active downgradient pumping, on-site treatment by advanced oxidation processes (AOP) and lime-soda softening, and a point source discharge to Lake Bemidji.
- Alternative 3 - Active downgradient pumping, on-site treatment by AOP and possible granular activated carbon (GAC) polishing, possible treatment by line-soda softening, and on-site discharge to an infiltration pond. Bioremediation may also be considered if the technology is sufficiently demonstrated prior to remedial action implementation.

The estimated present worth costs as presented by MP for the evaluated alternatives are:

Alternative 1	$300,000
Alternative 2	$3,000,000 to $6,200,000
Alternative 3	$1,800,000 to $6,200,000

The ROD issued by the EPA and MPCA selected Alternative 3 as the preferred remedy. Ground water would be collected with a series of pumping wells located within the present plume of VOC contamination. An on-site treatment facility will be constructed for removal of organic compounds by granular activated carbon (GAC), if necessary. Treatment for inorganics may be provided if contaminant concentrations exceed drinking water quality standards. Treated ground water will be discharged to an on-site infiltration basin for recharge to the aquifer. Ground water collection would continue for an estimated 4 to 30 years, depending on the long-term effectiveness of the landfill capping system in blocking further contaminant migration to ground water beneath the landfill.

3.0 CRITIQUE OF FS AND ROD ALTERNATIVES ANALYSIS

3.1 Introduction

The National Contingency Plan (NCP) lists nine criteria for evaluating remedial alternatives. They are overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; cost; state or support agency acceptance; and community acceptance. Of these nine criteria, the first two are considered threshold criteria that must be met or in the case of the ARARs, an ARAR waiver made.

As further discussed in Section 6.0, the FS and ROD do not support selection of Alternative 3 based on the nine criteria evaluation process required by the NCP. This section examines the technical merits of Alternative 3 and provides the basis for Section 6.0 reevaluation of Alternative 3 in comparison to other alternatives.

3.2 Review of Effectiveness of Ground Water Extraction to Attain ARARs

The Kummer Sanitary Landfill site ROD states: "The goal of this remedial action is aquifer restoration to a drinking water aquifer." (See ROD p. 16.) This section provides a literature review of the effectiveness of the pump and treat technology to restore aquifers to ARARs such as MCLs as prescribed by CERCLA and the NCP. This section contains three parts. First is a description of the physical and chemical processes limiting aquifer restoration feasibility. The second addresses the policy implications, particularly as related to establishing remediation objectives and evaluating pump and treat as a practicable remedial technology. The third addresses implications for remedial alternative development and selection for the Kummer Sanitary Landfill site.

3.2.1 Physical Processes Affecting Aquifer Restoration

The technical literature contains many articles that evaluate the effectiveness of pump-and-treat for aquifer remediation. The literature demonstrates that pump and treat technology is unable to reduce concentrations to levels below drinking water criteria (i.e., ARARs such as MCLs) in a time frame on the order of years or decades (Keely, 1989; Mercer, et al., 1990; MacKay and Cherry, 1989; EPA, 1989; Doty and Travis, 1991). The literature attributes the ineffectiveness of pump and treat to several physical processes. They are enumerated and briefly explained below. Greater detail regarding these processes is provided by Keely (1989), Mercer et al. (1990), MacKay and Cherry (1989), EPA (1989), Doty and Travis (1991), and other articles listed in the bibliography.

3.2.1.1 Continuing Sources and DNAPL

The presence of free product in the unsaturated zone or beneath the water table causes a long-term release of contaminants to the aquifer. For contaminants in the unsaturated zone, at least three mechanisms operate to produce releases to the aquifer. One is gravity-induced flow downward. A second mechanism is the leaching effect of downward moving recharge water from precipitation. The third mechanism is transfer of the free product to the pore vapor phase, migration of the vapor to the water table, and transfer of the contaminant mass to pore water at or near the water table. The latter two mechanisms may cause very long term mass input to an aquifer.

Sources of free product below the water table are termed dense non-aqueous phase liquids (DNAPL). DNAPL is free product which is denser than water (i.e., density greater than 1.0 g/cc). Halogenated solvents in their pure form are typically more dense than water. Trichloroethylene (TCE) and tetrachloroethylene (PCE) have densities of 1.47 and 1.63 g/cc, respectively. These DNAPLs will sink through an aquifer until the original mobile volume has been rendered relatively immobile on the aquifer matrix by capillary forces or has been dissolved in the ground water through which it passes.

The presence of DNAPL sources greatly complicates the assessment of pump and treat effectiveness and the prediction of the required treatment duration and costs. As a result of the significance of DNAPL to ground water remediation planning, the literature contains many articles on the topic. Some general articles are referenced in the bibliography (see Hunt et al., 1988; Cherry, 1990; Huling, 1991; Mercer and Cohen, 1990; Newell and Connor, 1991; Campbell, 1990; Newell et al., 1991).

3.2.1.2 Dissolution

Dissolution is the process of mass transfer from free product to the surrounding pore water. It operates when either mobile or immobile DNAPL is located within an aquifer. Immobile DNAPL takes the form of a residual phase in the pores of the aquifer. Ground water passes by the DNAPL due to ambient or pumping induced flow in the aquifer. As it passes by, mass transfers from the DNAPL phase into the dissolved ground water phase.

The DNAPL mass removal process is somewhat controlled by the rate at which ground water passes the DNAPL. Dissolution across the DNAPL-water boundary is diffusion limited, and thus the longer a parcel of ground water is in contact with the DNAPL, the higher the ground water concentration will become. For relatively slow moving ground water, the duration of contact for a parcel of fresh ground water with DNAPL is longest. In that case, chemical diffusion causes higher dissolved phase concentrations in the ground water than for the case of more rapidly moving ground water. In either case, many pore volumes of ground water are required to remove the DNAPL, if removal is possible at all.

Ground water remediation designed to rapidly flush the aquifer generally creates faster pore water movement past DNAPL and thus will result in lower concentrations per unit volume of ground water produced. A result observed at some sites is the dropping of concentrations to some level at which the system is shut down or changed, followed by an increase in concentrations in the aquifer. That phenomenon may be attributable to the generally lower pore water velocities which occur in an area of contaminated aquifer when pumping stresses cease.

3.2.1.3 Low Hydraulic Conductivity

Mathematical and computer modeling studies for pump and treat design typically assume aquifers are homogeneous. In reality, aquifers are heterogeneous and possess spatially variable hydraulic conductivity. The sequence of glacial deposits in the Kummer Landfill site area is an example of a heterogeneous hydrogeologic environment. The deposits consist of layers of clay, silt, sand or gravel, or mixtures of those constituents with varying thicknesses and lateral extent.

When a gradient is induced in a heterogeneous aquifer, ground water moves more readily through the zones of higher conductivity material. The result is that a large initial removal of mass may be realized, but removal of mass from the lower conductivity zones takes appreciably longer. Models which assume homogeneity would predict total mass removal in a shorter time frame.

The most extreme example of low hydraulic conductivity effects is that of contaminant mass in an aquitard. Aquitards typically possess a conductivity which is orders of magnitude less than that of the adjacent aquifer materials. Water moves very slowly through the aquitards due to natural, or pumping-induced, gradients. The aquitards may contain contaminant mass due to DNAPL presence, convective movement of contaminated ground water into the aquitard, and/or diffusion of contaminants from aquifer to aquitard pore water. Once in the aquitard, contaminants remain relatively hydraulically isolated. A change in the rate of aquifer pore flushing due to pump and treat remediation does not appreciably alter the rate at which contaminants diffuse from the aquitards. The result is a very long-term mass input to the aquifers.

3.2.1.4 Adsorption

Adsorption is the process in which the contaminant partitions between solution in ground water and temporary or permanent attachment to the aquifer matrix. Many organic constituents, including those observed at the site, have adsorptive tendencies. The most common model of adsorption is that which assumes a concentration dependent distribution of a chemical between the dissolved and adsorbed phases with instantaneous equilibrium (i.e., instantaneous desorption or adsorption).

Assuming the instantaneous, concentration-dependent adsorption-desorption model is valid, a "retardation factor" can be determined for a specific chemical in a specific environment. A retardation factor value of one indicates the chemical species moves at the same rate as the mean rate of ground water flow; a value of two indicates the chemical moves twice as slow as the ground water. That model may or may not be accurate for real systems but is commonly used in the literature. There is no doubt, however, that adsorbing chemical species move more slowly through an aquifer than do non-adsorbing species. That result has often been observed.

A common assumption in remedial alternatives modeling is to equate the retardation factor with the number of pore volume flushings required for restoration of the contaminated aquifer areas. In reality, aquifers are not restored in such predicted time frames and with such few pore volumes extracted. The cause of continued presence of contaminant mass may be due to other processes enumerated here. It may also be attributable to an oversimplification, or misunderstanding, of the adsorption process for a particular chemical species in a particular medium.

3.2.1.5 Stagnation

Stagnation is similar to the concept of hydraulic isolation in a low conductivity material. But stagnation can occur independent of the conductivity. It is caused by a balancing of competing hydraulic gradients -- either natural or induced by pumping. For example, if a well is located within a plume and a natural gradient is present, water at a point downgradient of the well will theoretically be stagnated eternally. In reality, ground water and pumping systems are somewhat transient and the stagnation point becomes an area in which ground water moves very slowly. Delayed removal of ground water from relatively stagnated aquifer areas results in a long-term presence of contaminants in the aquifer.

3.2.2 Published Opinions Regarding Restoration Feasibility and Policy

The literature reviewed for preparation of this section included publications in various forms and fora by a variety of environmental professionals. A plethora of technical publications exists which address the processes enumerated above in a scientifically exhaustive manner. Those articles are too numerous to list and are not overviewed here. The publications of interest here are those in which the technical limitations regarding aquifer restoration feasibility are fully understood by the author and in which the author makes statements regarding the effect of those limitations on current aquifer remediation objectives and policy. The important conclusions of these authors are quoted below. The quoted conclusions are direct and essentially speak for themselves.

The most recent major publication regarding aquifer restoration effectiveness was performed by two researchers at the Oak Ridge National Laboratories under contract with the Department of Defense (Doty and Travis, 1991). The primary conclusions of that study as stated in the Executive Summary are as follows:

Based on our review of performance records and recent theoretical studies, the following can be concluded regarding the use of ground water pumping for aquifer restoration:

- **Pumping is effective for contaminant mass reduction, plume containment, and extraction of ground water for point-of-use treatment. Its use for attaining these objectives should be encouraged.**

- **Ground water pumping is ineffective for restoring aquifers to health-based levels. This reality needs to be explicitly recognized by regulators.**

- **The primary contributors to the ineffectiveness of pumping in meeting cleanup goals are the time-dependent decrease in the rate of desorption of contaminants from contaminated soils and the existence of immobile contaminants either in the non-aqueous phase or trapped in zones of low permeability.**

- **Remedial time frames of 2 to 30 years were predicted at the sites reviewed. Regulators currently maintain that 20 to 40 years may be needed to reach health-based cleanup goals. However, recent modeling studies estimate pump and treat time frames of 100 to 1,000 years.**

The same authors state in an earlier publication (Travis and Doty, 1990):

> What are appropriate cleanup goals? In this intense debate, one question seems to have been forgotten: Is it technically possible to restore Superfund sites to an environmentally sound condition? For groundwater, the answer appears to be no. No matter how much money the federal government is willing to spend, at present contaminated aquifers cannot be restored to a condition compatible with health-based standards.
>
> In spite of intense searching, we were unable to locate a single aquifer in the United States that has been confirmed to be successfully restored through pumping and treating.
>
> Contaminants in groundwater partition between the water and organic matter in soils. As groundwater is pumped, the chemicals are held back (retarded) by their adherence to the soil particles. At sites involving NAPLs or zones of low permeability, the restoration process is complicated further. Even highly soluble contaminants may become trapped in the finer pore structure because groundwater pumping causes preferential flow in high-permeability zones.
>
> Approximately 76 percent of Superfund sites for which pumping and treating is selected as the aquifer restoration method are contaminated by trichloroethylene (TCE), a contaminant denser than water . . . . The geometric mean for the maximum concentration of TCE detected in groundwater at the 50 sites we reviewed . . . was 845 ppb with a range of 2-81,000 ppb. The MCL for TCE is 5 ppb. Thus, for groundwater pumping to restore the average Superfund site, pumping must remove more than 99 percent of the mass of TCE in the dissolved and nonaqueous phases. It is well known that even with enhanced oil recovery methods, oil companies can only remove 30 to 50 percent of the oil from the sub-surface. One wonders why Congress believes that EPA can remove organics from groundwater more effectively than oil companies which could make billions of dollars by improving oil recovery by 5 to 10 percent.

After reviewing the Travis and Doty (1990) article and analyzing the EPA's then-current position, Rowe (1991), a remedial project manager for EPA Region 6, concludes:

> Travis and Doty have made some good recommendations and it is obvious that EPA has recognized the value of many of them. What remains ahead for EPA is a difficult task of dealing with residual groundwater contamination. In spite of many active restoration efforts, residual contamination will persist at many sites, requiring a management strategy that balances active restoration, waivers, alternate concentration limits, and source control efforts.

In notes for a short course on DNAPL an eminent hydrogeologist, Dr. John A. Cherry, states (Cherry, 1990):

> [P]ermanent cleanup of subsurface sources at DNAPL sites (i.e. removal of the residuals and pools below the water table) to achieve drinking water levels is almost never feasible for a number of reasons, including the fact that drinking water or other health-based standards (MCL's, ARAR's) for many DNAPL derived chemicals are at the parts per billion level and the fact that current established technologies are relatively ineffective.
>
> [F]ailure to recognize clearly the relevance of the DNAPL paradigm at Superfund, RCRA or other such sites can result in remedial action costing millions or tens of millions of dollars (or more) per site, that accomplish little technically towards permanent site cleanup or towards proper protection of human health and the environment.

Further conclusions regarding the significance of DNAPL are provided by Huling and Weaver (1991) and Hunt et al. (1988). Huling and Weaver (1991) state:

> Dense nonaqueous phase liquids (DNAPLs) are present at numerous hazardous waste sites and are suspected to exist at many more. Due to the numerous variables influencing DNAPL transport and fate in the subsurface, and consequently, the ensuing complexity, DNAPLs are largely undetected and yet are likely to be a significant limiting factor in site remediation.

Hunt et al. (1988) conclude:

> The movement of the separate phase is controlled by capillary forces, and ganglia displacement by groundwater is not possible under reasonable hydraulic gradients. In addition, because of mass transfer limitations in liquid phase dissolution, groundwater extraction at contaminated sites is shown to be ineffective in removing the nonaqueous contaminant within a reasonable time frame.

In a publication which focuses mostly on the effects of adsorption, Clinton W. Hall of EPA's Robert S. Kerr Environmental Research Laboratory generally concludes:

> The perceived success of pump and treat technology can be misleading if the hydrology and contaminant characteristics at the site are not adequately understood. A failure to understand the processes controlling contaminant transport can result in extremely long pumping periods and, consequently, costly and inefficient remediation.

MacKay and Cherry (1989) provide an overview of the processes causing indefinite aquifer restoration time and state in the introduction:

> Almost all remediation of groundwater at contaminated sites is based on groundwater extraction by wells or drains, usually accompanied by treatment of the extracted water prior to disposal. This often causes an initial decrease in contaminant concentrations in the extracted water, followed by a leveling of concentration, and sometimes a gradual decline that is generally expected to continue over decades. In such cases, the goal of reaching stringent health-based cleanup standards is very remote and the ultimate cost of cleanup very high.

Schiffman (1989) authored an editorial comparing the regulatory policies of the Clean Water Act for surface water cleanup to those of CERCLA for ground water remediation. Mr. Schiffman, then assistant director of the Division of Water Resources, New Jersey Department of Environmental Protection, states:

> The objective of most active cleanups of contaminated ground water is to restore the ground water to use as a water supply without treatment. This objective is not realistic. First, a cleanup achieving health-based drinking water standards cannot assure protection of public health. At the time of cleanup, it is not possible to either predict changes to the standards (today's limit of laboratory detection often becomes tomorrow's standard) or analyze for compounds that may have standards in the future. While public water supply systems can respond to more stringent standards with improved treatment, individual homeowners with wells cannot. Second, it is not yet technically feasible to reliably clean up contaminated ground water to very low or non-detectable levels. The variability and complexity of natural systems in aquifers makes it extremely difficult to model and predict the fate and transport of contaminants in ground water. Many aquifers consist of layers of sands, silts, and, [sic] gravels of different permeabilities; pumping contaminated ground water out of these aquifers can result in preferential cleanup of the higher permeability layers over the lower permeability ones. The ground water can appear to be clean when there is actually substantial contamination remaining in the layers of lower permeability. In addition, some common classes of chemical contaminants are difficult to remove from aquifer systems. Non-aqueous phase liquids (so-called "NAPLs") persist in the unsaturated and saturated zones of aquifers as unpredictable globules, making their complete removal nearly impossible. Lastly, one must recognize that unconfined aquifers are vulnerable to contamination from man's activities; even if a contaminated unconfined aquifer could be completely cleaned up, there would still be a substantial risk of it becoming contaminated again as compared to health-based drinking water standards. This risk of contamination is the reason public water supplies obtained from streams are treated prior to delivery to the consumer.

> The problem in cleanup of ground water is not the cleanup standards themselves ("how clean is clean?") but the need for a regulatory framework to determine the appropriateness of where and when to apply them.

In addition, the EPA has not been silent on the issue of aquifer restoration to ARAR levels. In fact, the EPA has funded or contributed to studies of the effectiveness of the pump and treat remedy. The EPA completed a major evaluation of ground water extraction remediation in 1989 (EPA, 1989b; EPA, 1989c). The EPA screened 112 sites where ground water extraction remedies had been implemented (EPA, 1989b). Nineteen of the sites were considered to have sufficiently long extraction system durations for a detailed evaluation. The case studies are provided in EPA (1989c). A summary report of the evaluation stated the following "Study Findings" (EPA, 1989b):

> Trends identified from the 19 case studies lead to the following general conclusions:
>
> - The ground-water extraction systems were generally effective in maintaining hydraulic containment of contaminant plumes, thus preventing further migration of contaminants.
>
> - Significant removal of contaminant mass from the subsurface is often achieved by ground-water extraction systems. When site conditions are favorable and the extraction system is properly designed and operated, it may be possible to remediate the aquifer to health-based levels.
>
> - Contaminant concentrations usually decrease most rapidly soon after the initiation of extraction. After this initial reduction, the concentrations often tend to level off and progress toward complete aquifer restoration is usually slower than expected.
>
> - Data collection, both prior to system design and during operation, was frequently not sufficient to fully assess contaminant movement and the response of the ground-water system to extraction.
>
> Three different remedial objectives have been identified for the ground-water extraction systems described in the case studies: aquifer remediation, migration control, and well-head treatment. Aquifer restoration for the purposes of this report means that the contaminant concentrations in the aquifer are to be reduced below specified levels that have been determined to be protective for the site. In the case of Superfund sites, the cleanup levels are either the regulatory Maximum Contaminant Levels (MCLs) or 10^{-4} to 10^{-6} excess cancer risk concentrations. Of the 19 sites

> studied in detail, 13 had aquifer restoration as their primary goal, and only 1 has been successful so far. Several of the other systems show promise of eventual aquifer restoration, but typically progress toward this goal is behind schedule. Concentrations often decline rapidly when the extraction system is first turned on, but after the initial decrease continued reductions are usually slower than expected.
>
> The operational experience described in the case studies indicates that success in aquifer restoration depends on favorable aquifer and contaminant characteristics, and on appropriate system design. Sites that are favorable for aquifer restoration have relatively simple stratigraphy with fairly homogeneous unconsolidated aquifer materials and contaminants that are present primarily as dissolved constituents in the ground water. Most departures from these ideal conditions tend to impede the progress of aquifer restoration. However, even if the concentrations are not rapidly reduced to cleanup goals, the extraction systems may still significantly reduce contaminant mass in the aquifer.

In an EPA policy statement, Jonathan Cannon, Acting Assistant Administrator of the Office of Solid Waste and Emergency Response restated the findings of the study (EPA, 1989a). Of particular significance is the characterization of the effectiveness of extraction systems to reach cleanup goals:

> Concentrations of contaminants have generally decreased significantly after initiation of extraction but have tended to level off after a period of time. At the sites examined, this leveling off usually began to occur at concentrations above the cleanup goal concentrations expected to have been attained at that particular point in time.
>
> Several factors appear to be limiting the effectiveness of the extraction systems examined, including:
>
> - Hydrogeological factors, such as the heterogeneity of the subsurface, the presence of low permeability layers, and the presence of fractures;
> - Contaminant-related factors, such as sorption to the soil, and presence of non-aqueous phase liquids (dissolution from a separate non-aqueous phase or partitioning of contaminants from the residual non-aqueous phase);
> - Continued leaching from source areas;
> - System design parameters, such as pumping rate, screened interval, and location of extraction wells.

Another policy statement regarding the findings of the EPA (1989b) study was contained in an editorial letter by EPA's Bill Hanson, Chief of the Remedial Operations and Guidance Branch (EPA, 1990). After restating the conclusions of the EPA (1989b) study, Mr. Hanson states:

> Where data indicates that portions of the contaminant plume cannot be reduced to levels reflecting the beneficial uses of the ground water either through extraction or more innovative methods, institutional controls should be provided to prevent access to contaminated ground water and containment of contaminated areas should be continued where warranted.

Yet another EPA statement by Henry A. Longest II, Director of the Office of Emergency and Remedial Response was offered to establish EPA's position on ground water extraction (EPA, 1991). That statement is an editorial letter written, in part, to respond to the Travis and Doty (1990) comments regarding restoration feasibility. Mr. Longest states (EPA, 1991):

> While Superfund shares Travis and Doty's concerns for the limitations of groundwater extraction systems, data and experience at this time are insufficient to conclude that no contaminated groundwater can be restored.
>
> Further, Superfund policy does, in fact, allow for establishing alternative goals to full restoration for portions of contaminated plumes that cannot practicably be restored with currently available technology, or do not warrant active restoration based on site-specific factors, including existing poor water quality and remote site location. For sites meeting the above criteria, containment or natural restoration may replace full restoration as the remedial goal. Maintaining an overall goal of restoring contaminated ground water, with site-specific flexibility to modify this goal, provides incentive for developing and using new innovative technologies and approaches for groundwater cleanup, and preventing contamination from occurring in the first place.
>
> EPA continues to fund research on groundwater cleanup and sponsored a workshop in April 1990 on strategies for addressing sites with DNAPL sources. Groundwater cleanup is and will remain a key implementation issue as we gain additional insight and experience in pump-and-treat and other groundwater remediation technologies.

The statements of Mr. Longest indicate EPA recognizes the need to establish "alternative goals" for ground water which "cannot practicably be restored with currently available technology. . . ." (EPA, 1991). Similar conclusions were made in the publication by Haley et al. (1991), the primary authors of which are EPA technical personnel:

> The findings of this study indicate that ground water extraction is an effective method for preventing additional migration of contaminant plumes and achieving risk reduction. However, the findings indicate that in many situations, it may not be practicable to rely solely on ground water extraction and treatment to achieve health-based cleanup concentrations throughout the contaminated zone and fulfill the primary goal of returning ground water to beneficial use.

The Office of Technology Assessment has also conducted an assessment of ground water extraction (OTA, 1989). That study concludes:

> There is a higher degree of uncertainty regarding the effectiveness of groundwater extraction systems than is conveyed by Superfund Records of Decision (ROD).
>
> Source identification and removal should be given a higher priority, because groundwater contamination is difficult to remediate.
>
> Groundwater extraction should continue until it is clear that the contaminant concentrations cannot be reduced further and no other remediation options exist.
>
> In some cases, natural attenuation may achieve the same results as groundwater extraction.

3.2.3 Implications for Remedial Alternatives Development and Selection

Publications by environmental professionals accurately document the physical and chemical processes responsible for the observed long-term sustaining of ground water concentrations at levels above ARARs for sites with active pump and treat remediation. The contributing processes include effects of continuing sources (DNAPL), dissolution, low hydraulic conductivity, adsorption and stagnation. Authors with knowledge of these processes have concluded that aquifer restoration to health-based ARARs is not feasible, or is possible only through indefinite remediation with associated exorbitant cost.

The EPA has similarly concluded that aquifer restoration to health-based ARARs often may not be feasible. EPA personnel have indicated that such aquifer restoration may not be the required goal where site-specific circumstances render such restoration impracticable.

Based on CERCLA and NCP requirements, the overall objective of the remedial actions are to protect human health and the environment and to comply with ARARs in a reliable and cost-effective manner. The NCP requires ground water restoration to MCLs which are ARARs for this site. The ROD adopts that objective of attainment of ARARs for ground water restoration (see ROD p. 16). Significantly, that objective is not contained in the FS discussions of ground water remedial alternatives development and analysis. Given the state of the science of ground water hydrology as reflected in the literature review and, particularly, in the recent Oak Ridge National Laboratories report, restoration to ARARs cannot be achieved in a reasonable time frame, if at all, using ground water extraction. The Kummer Sanitary Landfill site characteristics do not indicate that restoration to MCLs is any more feasible than restoration at other sites which were the subject of the referenced literature review studies. The processes which cause very long-term levels of contaminants in an extraction system may all be expected to exist, to varying degrees, at the site. Therefore, a "technical impracticability" waiver of those ARAR requirements is warranted under CERCLA section 121(d)(4) and the NCP subparts 300.430(g)(2)(v), (f)(1)(ii)(C).

If restoration to MCLs is retained as a cleanup goal, Alternative 3 is not the most cost-effective means to attempt to achieve that goal. The FS and ROD evaluations of Alternative 3 are inaccurately low in cost and over-optimistic on effectiveness. Alternative 3 is estimated in the FS to cost up to 6.2 million dollars for the first 30 years. The extraction system operation and maintenance (O & M) costs are ignored past a 30 year operation period, and an unrealistic discount rate is used to calculate the present value cost even for the 30 year period. The literature review indicates aquifer restoration, if possible at all, requires much more time than the 30 year period assumed for cost estimation purposes in the FS. The longer period of operation in turn produces higher present value costs for annual O & M costs associated with the extraction system. This is particularly important if a lower, and more realistic, discount rate than the ten percent value assumed in the FS is used in the present value calculations. Regarding effectiveness, Alternative 3 is not likely capable of attaining ARARs (restoration to MCLs) in 30 years. Further, Alternative 3 does not address a portion or the plume which will not be captured by the extraction system and which will migrate downgradient. Alternative 3 offers only containment of a portion of the plume and most likely will not restore that portion to ARARs within the assumed 30-year cleanup period.

Alternative 3 is therefore a very expensive remedy which is not totally protective of human health and the environment nor capable of attaining ARARs. In addition, Alternative 3 transfers contaminants from one media to another and may create a hazardous sludge as a result of the treatment process. This creation of this potentially hazardous sludge may violate an ARAR. As a result, other options such as plume monitoring and bioremediation should be considered which are equally, or more, effective than Alternative 3 at protecting human health and the environment and which have lower associated cost. Selection of a higher cost remedy which is less, or equally, effective than a lower cost alternative violates the NCP requirement for cost-effectiveness.

3.3 Ground Water Modeling

3.3.1 Purpose

The purpose of conducting the computer modeling of the aquifer system was to:

- Predict migration of the contaminant plume since sampling was last conducted in 1989.
- Predict migration of the contaminant plume if no remedial activities, other than capping the landfill, are conducted.
- Evaluate the effectiveness of the pumping and treatment system described in the ROD.

3.3.2 Model Description, Input Parameters, and Calibration

The model selected for the evaluation is the Single Layer Analytic Element Model (SLAEM) (Strack, 1989). The model is a two-dimensional analytic model suitable for analyzing ground water flow and contaminant transport in confined or unconfined aquifers.

The input parameters used were within the ranges used in the model developed by MP with the exception of the elevation of the base of the aquifer in the north and west part of the study area. Both models made the simplifying assumption that the aquifer was single-layer even though wells had been installed at three different levels. The models best describe ground water flow near the upper part of the aquifer. The model input file is included in Appendix A.

The Delta model input file is included with this report. Some important features of the Delta model are:

- Hydraulic conductivity of 45 ft/day.
- Porosity of 0.23
- Regional rainfall infiltration rate of 3 in/yr.
- Regional aquifer base elevation of 1,280 ft.
- Area of lower hydraulic conductivity (25 ft/day) north of the landfill.
- Area of higher aquifer base elevation (1,320 ft) east and southeast of the landfill.
- Constant head in Lake Bemidji of 1,339 feet.
- Constant head in Grass Lake (southwest of the landfill) of 1,373 feet.

The area of lower hydraulic conductivity corresponds to a localized area of clay lenses which MP reported in their drilling logs and cross sections. Similarly, the area of higher aquifer base elevation corresponds to reported a thinning of the aquifer due to till layers south and southeast of the landfill.

Model results for the aquifer at steady-state conditions are shown on Figure 1. The results are sufficiently similar to the ground water contours generated from water level data collected August 14-15, 1989, as reported in the RI. Using the model's streamline function, the predicted migration of the contaminant plume away from the landfill also matched the actual field data, especially to the northeast of the landfill. The migration of the deeper contamination to the southeast was not simulated as accurately.

3.3.3 Plume Migration

Predictions of the present extent of the contaminant plume were made using the calibrated model and the 1989 data. SLAEM's streamline function predicts travel time based on the hydraulic conductivity, porosity, and the calculated local gradient. A retardation factor may also be included in the calculation, but it was not included in this problem. Dispersion was also neglected. The streamline function was used to predict the migration of the plume due to advection over the two-year time period of 1989-1991. The results are shown on Figure 2.

Two methods were used to predict the contaminant travel times to Lake Bemidji. Both methods calculated the travel times based on ground water advection. The first method calculated the travel times using the ground water level data presented in the remedial investigation and the formula:

$$t = \Sigma \frac{\Delta x}{Kin} = \frac{\Delta x^2}{k \Delta h n}$$

Where:

t = travel time
K = average hydraulic conductivity
i = gradient
n = porosity
Δx = distance traveled
Δh = ground water elevation

The method has the advantage that is based on actual field data.

The second method used the calibrated SLAEM model as described above. This method had the advantage that it included the influence of the clay cap which was placed on the landfill in August 1991. U.S. EPAs HELP model was used to predict the decrease in infiltration rate caused by the cap. The input parameters and results of the HELP model are included in Appendix A. The model predicted that the cap would reduce infiltration from 3.0 inches to 1.8 inches per year.

The results of the two methods were nearly the same. The predicted travel time from the landfill to Lake Bemidji was between 30 and 40 years depending on the contaminant's place of origin in the landfill. The predicted travel time from the eastern front of the plume to Lake Bemidji was between 15 and 18 years depending on which part of the plume was considered. MP determined that the front of the plume would reach Lake Bemidji in 34 years. The predicted travel time to Lake Bemidji is different from MP's model because dispersion and retardation were not considered. Note that the concentration of contaminants has not been predicted.

3.3.4 Evaluation of FS Alternative 3 Pumping System

Three significant problems with the proposed pumping system and MP's modeling were identified using the SLAEM model. These problems negatively reflect upon the reliability and effectiveness of Alternative 3 and the accuracy of the cost estimate for that alternative.

The first problem with the MP model is that the software used is not precise enough for the design problem. MP used the Prickett Lohnquist Aquifer Simulation Model (PLASM), a finite-difference model, for its analysis. Because of the large study area, a coarse model grid had to be established in the area of the landfill. The five proposed wells were spaced over only nine or ten grid spacings. This meant that the locations of the simulated wells had to be shifted significantly to fit the model grid spacings. When wells are placed in such close proximity in the model, mathematical errors are possible. The results were apparently contoured using the program SURFER (Golden Software). The influence of a single well in the model is averaged over the area of the grid node. The contouring program draws contour lines based on this one averaged value which has been influenced by the averaged values in adjacent grid spaces. The results presented in MP's report are too detailed for the amount of data put into the model and the contouring program. The Delta SLAEM model does not have these problems because it is an analytical, not numerical, model. The mathematical equations it uses can be solved exactly for any point. For this reason, the small area between the proposed wells could be examined more closely to determine that complete capture may not be possible at the proposed 85 to 100 gpm pumping rates.

The second problem with the MP model is that the remediation system design called for an infiltration pond to be constructed along the north side of the landfill to dispose of water from the treatment system. The MP model did not include increased infiltration due to the pond. As can be seen on Figure 3, it will have a significant influence on ground water flow.

The third problem is the assignment of representative hydraulic conductivity value. Both models are very sensitive to the hydraulic conductivity values selected. MP assigned values of five to ten gallons per day per foot (See FS Appendix B, page 10) to the aquifer area near the extraction wells. These are significantly less than the reported regional hydraulic conductivity of 45 ft/day. No justification is presented for the low values, which are lower than any of the slug test or pumping test results. Also, the nearest well for which hydraulic conductivity data are reported is located in the landfill approximately 900 feet west of the pumping area, and MP reports that the hydraulic conductivities are variable across the site. Lower hydraulic conductivity values will produce greater predicted areas of extraction well capture for any given well discharge rate.

To evaluate the significance of the range of possible hydraulic conductivity values, the proposed pumping scenario was input into the SLAEM model using the regional hydraulic conductivity of 45 ft/day. The model predicted that even when the pumping wells reached steady state, the proposed combined pumping rate of 85 gpm or even 100 gpm would be insufficient to capture all of the contaminants emanating from the landfill. The model results and proposed capture zones are shown on Figure 3. The SLAEM model also indicates that a combined pumping rate of at least 150 gpm would be necessary to provide complete capture of the contaminants coming from the landfill. This higher pumping rate would result in higher treatment and waste disposal costs than originally estimated. The MP model is based on tenuous data which should have been confirmed before project costs were estimated.

3.3.5. Conclusions

The conclusions of the ground water modeling using the SLAEM model are:

- The contaminant plume is predicted to presently cover the area indicated on Figure 2.

- The proposed recovery well configuration and pumping rate may not be adequate to capture contaminated ground water leaving the eastern landfill boundary. A greater pumping rate is probably required than predicted by MP if total capture at the landfill boundary is the objective. The higher required pumping rate results from MP's use of possibly inaccurate conductivity data, the omission of the infiltration pond in their model, and the inherent limitation of the software used. As a result Alternative 3 is of questionable reliability and its cost could be greatly underestimated. Hydraulic conductivity data from wells closer to the proposed area of the extraction wells should be obtained before final costs are estimated.

- The proposed pumping system will have no effect on the downgradient extent of contamination.

3.4 Review of Recommended Treatment Alternative

The recommended treatment process includes the pre-treatment of the ground water to remove inorganic contaminants. This pre-treatment raised concerns in both the ROD and FS which have not been fully addressed. The main concern is the generation of sludges with concentrations of inorganics such as barium and arsenic which could create the need to dispose of a hazardous waste. The ROD and FS do not directly indicate the level of inorganic contaminants that can be expected in the resultant sludge produced by the treatment process, nor specifically provide disposal options or costs if the material is deemed hazardous.

The recommended treatment process in the FS estimates treating 100 gallons per minute of ground water and generating 1 cubic yard per day of associated sludge at 50 percent solids. The estimated influent to the treatment system is expected to contain 82 ug/l barium and 14 ug/l of arsenic which if removed at an assumed 90 percent efficiency would generate 0.0887 pounds of barium and 0.0151 pounds of arsenic per day within the associated sludge. This would equate with a barium concentration of 98.556 parts per million (ppm) by weight and 16.778 ppm arsenic by weight in the sludge.

In order to assess the toxicity of the sludge and determine if it is to be classified as a hazardous waste for disposal, the toxicity characteristic leachate procedure (TCLP) must be performed on the sludge. If the results of the TCLP are 100 mg/l or greater for barium or 5 mg/l or greater for arsenic, the sludge is classified as a hazardous waste and must be treated before disposal. If the TCLP results indicate the material is not hazardous, then the sludge does not require treatment before disposal.

Treatment options for a hazardous waste of this type would center on stabilization technology whereby the waste is mixed with cement, flyash, or similar materials to solidify and prevent the generation of toxic leachate. The resultant material is then disposed in a RCRA landfill facility. The RCRA facility in Lone Mountain, Oklahoma, operated by USPCI would be one choice for permitted disposal.

If determined to be non-hazardous, disposal could potentially be performed at a sanitary landfill; however, the reasonableness of disposing of a material, which has been generated from remedial work at one landfill, in another landfill, is highly questionable. There is also the question of what landfill in the Bemidji area, or even statewide, would accept such a material because of its origins. Disposal would likely therefore need to be performed at a RCRA landfill which would be less apt to reject the material because of its composition; however, additional transportation costs would then become necessary. Disposal of the sludge to an out-of-state facility also poses a health and environmental risk during transport.

The estimated costs for transportation of the material to a RCRA facility, such as the USPCI facility in Lone Mountain, Oklahoma, depends first of all on the type of material to be transported. If the material is sludge at 50 percent solids as estimated to be produced in the FS, the transportation cost is approximately $3,300 per 4,500 gallons based upon transport by suction tanker truck. If the material can be dewatered further and transportation can be performed by covered gondola box, transportation costs could be arranged at a rate of approximately $2,500 per 20 cubic yard container; however, this would require additional treatment equipment, such as a filter press, adding to capital and operation and maintenance costs. If treatment is necessary, the Lone Mountain ~~facility~~ would also treat the material. If the material is over 15 percent liquid, it could be treated as a waste water for which costs are $0.07 per pound, but much of the material to be treated would be water. If the material is dewatered to where it can be treated as a solid (less than 15 percent liquids) instead of a sludge, then treatment by stabilization techniques can be used. Stabilization costs for solids are estimated at $0.07 per pound as well, but less material would need to be treated.

In either case, whether the material is considered hazardous or non-hazardous, and greater or less than 15 percent solids, disposal in the landfill will be required. Disposal is estimated at $0.07 per pound for both treated hazardous and non-hazardous waste. This would equate to a cost for transportation and disposal in a RCRA facility of $100,000 to $144,500 per year based upon the estimated sludge generation rates given in the FS, with the higher costs associated with the material if it is deemed hazardous. This is $20,000 to $64,500 more than the $80,000 estimated for annual sludge disposal in the FS.

In addition to the generation of barium contaminated sludge, the treatment process calls for the use of GAC to polish the discharge from the treatment system. The GAC would be used to remove potential unknown contaminants that may be present in the ground water as well as volatile organic compounds which are not fully destroyed in the AOP process. The use of GAC to remove organic compounds is well documented. But for any case where GAC is used, there are concerns for the cost and techniques available for disposal of the GAC once it is spent. In addition, potential unknown contaminants may be present to adsorb onto the GAC. Current regulations may allow for the regeneration of the spent GAC depending on the contaminants. In general, the GAC suppliers are willing to regenerate the carbon if the contaminants are consistent over time. However, the acceptance and disposal of the carbon remains the responsibility of the generator (i.e., the city of Bemidji). How GAC is transported and disposed depends again on whether it is hazardous. A TCLP analysis would need to be performed on the GAC.

In addition to the potential problems caused by disposal of the lime sludge and spent GAC, modeling of the pumping scenario recommended in the FS and ROD resulted in data which indicates a pumping rate closer to 150 gallons per minute (gpm) will actually be necessary. If the rate of ground water pumping is increased 50 percent to 150 gpm then the amounts of sludge, barium, and arsenic produced by the treatment process will also increase 50 percent. This will also increase the costs associated with sludge disposal and GAC treatment of disposal by 50 percent. A comparison of the consequences of pumping at 100 gpm versus 150 gpm are presented in Table 1.

The end result is that the treatment alternatives presented in the FS have associated long-term negative impacts (including cost and liability) dependent upon the disposal method required for the sludge and the GAC. The recommendations of the FS are not a permanent solution to the current problem and could in fact, create new problems in the future. The FS stated that the long-term effectiveness associated with the landfilling of sludge is unknown (FS page 4-7).

3.5 Present Worth Analysis

The recommended treatment alternative in the ROD includes cost information which estimates present worth of capital, and O & M costs at $1,800,000 to $6,200,000. These present worth values are based upon a $1,000,000 to $1,400,000 initial capital investment and $240,000 to $510,000 per year O & M for 4 to 30 years, with the higher costs associated with treatment to remove inorganic contaminants. The FS uses an effective discount rate of 10 percent for the present worth analysis.

The use of a discount rate of 10 percent implicitly assumes that money invested today for the capital and O & M costs over the life of the project would earn a 10 percent premium over the inflation rate. In other words, the present worth analysis assumes that if the City were to set aside money at the full value of the present worth today, it would be able to obtain a return on that money at a rate 10 percent greater than the inflation rate for the entire period of remediation. This would be necessary in order to have that money meet the needs of O & M over the life of the project.

The assumption of a 10 percent premium of investment return over inflation is unsubstantiated in the ROD or FS and is historically unreasonable. Conservative investment returns of 8 percent to 9 percent are possible today; but with inflation at approximately 5 percent the effective discount rate is presently 3 to 4 percent. If the present worth analysis is performed with the escalation of O & M costs due to inflation factored in at an average rate of 6 percent and investment return rate is assumed to be 10 percent, the effective discount rate would be 4 percent, and the present worth changes dramatically. For inorganic treatment, the present worth based on the same initial capital and O & M costs becomes $3,300,000 to $10,800,000 for 4 to 30 years. Table 2 summarizes the present worth costs of the recommended alternatives and the effect that inflation can have on present worth. The inclusion of inflation effects causes the worst case costs for the total project to jump from the $6,200,000 estimated present worth in the ROD to $10,800,000 as estimated here. Appendix B includes the summary of each present worth calculation. The present worth analysis provided by the FS underestimates the cost escalations that will occur due to inflation, assumes a high discount rate, and as a result misrepresents the potential project life cost of this treatment process to the city of Bemidji.

4.0 EVALUATION OF HEALTH RISKS AND ARARS

Since the ROD was issued for OU3 the significance of ground water as a human exposure pathway has decreased. Thus, the RI baseline health risk assessment is reanalyzed here to assess the need for remedial action.

The purpose of the following discussion is to describe:

- The assumptions and conclusions of the human health assessments previously performed for the site.
- How these conclusions are affected by the recent issuance of a well advisory by MDH.
- Additional administrative controls which, along with plume monitoring, would significantly decrease human health risks at the site related to ground water exposure.

4.1 Background Documents Describing Health Risks Under A No-Action Alternative

The public health and ecological impacts of the Kummer Sanitary Landfill were described qualitatively and quantitatively in four documents:

- Health Assessment for Kummer Sanitary Landfill published by the Agency for Toxic Substances and Disease Registry (ATSDR) on June 27, 1989.
- Remedial Investigation Final Report, Kummer Sanitary Landfill, Minnesota Pollution Control Agency, January 1990.
- Feasibility Study, Final Report, Northern Township, Beltrami County, Minnesota Pollution Control Agency, July 1990.
- Record of Decision, U.S. EPA, September 1990.

4.1.1 ATSDR Health Assessment

A qualitative baseline risk assessment was performed by the MDH for ATSDR. The ATSDR report evaluated the contaminants of concern based on their exceedance of the Minnesota Recommended Allowable Limits (RALs). The following VOCs were found to be the contaminants of concern:

- vinyl chloride (VC)
- tetrachloroethylene (PCE)
- 1,1,2-trichloroethylene (TCE)
- benzene
- trans-1,2-dichloroethylene (t-DCE)

Barium concentrations in ground water were noted to be above the then current EPA secondary drinking water standards, but not found to be of significant health concerns. Currently barium is listed with a MCL for drinking water of 1,000 ug/L, but has a proposed MCL of 2,000 ug/L to be effective July 1992.

The report found human exposures to contaminated ground water to be of greatest concern.

4.1.2 Remedial Investigation

In the RI a quantitative analysis of the risks associated with potential exposures to the contaminants in ground water was carried out according to the Superfund risk assessment guidelines (U.S. EPA, 1989). Ground water was found to be the pathway of concern, and exposures of wildlife or humans via the wetland, or Lake Bemidji were not expected to be significant. As summarized in the ROD, the contaminants of concern were the five VOCs listed in the ATSDR report. It was assumed that the ground water concentration for each contaminant at a receptor was at the maximum concentration measured during the RI. Potentially completed exposure pathways to ground water were by the ingestion, inhalation, and dermal exposure routes. Inhalation and dermal exposures were based on exposures during showering only. Both chronic and carcinogenic endpoints were estimated with the available toxicity parameters (potency slopes and Reference Doses RfDs). By this analysis the risks associated with oral ingestion of 2 liters/day of water contaminated with 94 ug/L VC was the most significant contribution to a risk of approximately 3×10^{-3}.

The analysis demonstrated that VC is the contaminant with the most significant risk. The analysis indicated that for a receptor using the contaminated ground water at the plume maximum concentration, a risk greater than the Superfund range of acceptable risks (10^{-4} to 10^{-7}) would be present.

4.1.3 Feasibility Study

In the FS a no-action alternative was evaluated in terms of the human health risks. The human health risks associated with drinking water exposures were considered insignificant. The exposure pathway from the ground water to the public was assumed to be incomplete based on the connection of the affected businesses and residences to an alternative water supply and a long-term well drilling advisory to be implemented and enforced by the MDH.

On this basis the Minnesota Surface Water Quality Criteria (SWQC) were selected in the FS as ARARs for the site. The impact to surface waters was considered to be the most significant pathway for human exposure.

The significance of the plume discharging to Lake Bemidji was evaluated in the FS using a random walk contaminant transport model. The results of the model indicated that concentrations of VOCs in ground water discharging to Lake Bemidji would not exceed 5 ppb anytime in the next 80 years. It was concluded that "no-action is likely to be protective of human health based on modeling projections of ground water quality at Lake Bemidji" (FS, page 4-3).

4.1.4 ROD/Administrative Order Summary of Health Risks at the Site

Despite the incomplete exposure pathway assumption in the FS, Table 4 of the ROD demonstrates that the EPA has directed the clean up goal to be MCLs for the five listed VOCs. This was based on the assumption that there could still be some potentially completed ground water exposure pathways.

The ROD states that:

- Contaminants of concern are vinyl chloride, benzene, tetrachloroethylene, trichloroethylene, and trans-1,2-dichloroethylene (in the Administrative Order barium and arsenic were also identified).

- Ground water is the key exposure pathway.

- Vinyl chloride is the contaminant which poses the most significant risk.

- Under a no action alternative, surface water impacts would be expected to be insignificant. The exposure pathway via Lake Bemidji is considered low risk (page 9 of the ROD) and the discharge to Lake Bemidji appears to comply with SWQC (page 10 of the ROD).

4.2 Changes in Site Characterization

The most important change in conditions since the ROD was signed is the issuance of a well advisory for the area potentially impacted by the plume. This should significantly decrease the human exposure to the contaminants of concern by the ground water pathway.

The MDH Well Advisory is reproduced in Appendix C. The advisory includes the areas currently impacted by the plume and the areas which may be impacted in the future. The advisory area is split into two portions by a vertical line defined by Tamarack Avenue. In the area west of Tamarack Avenue, where the plume is currently located, all wells (other than monitoring wells) must be abandoned unless the homeowners can demonstrate through a single sampling that the ground water is free of any contaminant above the RALs. The well advisory also states that the "restrictions and boundaries of this advisory area may change." In effect, as the contaminant plume migrates to the east beyond Tamarack Avenue, the strictest well abandonment area will also expand.

Well owners east of Tamarack Avenue are not currently required to test or abandon their wells unless there is a property transfer, at which time the requirements are equivalent to those covering the western area of the advisory. No additional drilling or well deepening will be permitted in the advisory area with the exceptions stated in the Well Advisory.

Currently, there remains a potential for human exposures to the contaminated ground water via ingestion, inhalation, or dermal contact. For the following reasons it is recommended that additional administrative and institutional controls be implemented to prevent human exposures to the ground water:

- At present, four parties have not hooked-up to the municipal water system and are still using ground water for drinking water and other domestic uses. These cases are being pursued in court to force them to connect to the municipal water supply system.

- The plume is moving toward Lake Bemidji. With or without any remedial action eventually some of the plume will cross the boundary of Tamarack Avenue defined by the MDA well advisory. At that time the well advisory and the requirement of well abandonment will have to expand to eliminate the public risk.

A second recent development pertinent to the site is the adoption of updated SWQC. Table 3 is provided to show the current values of the MN SWQC for Lake Bemidji. These ARARs have changed since they were tabulated for the RI and Table 4 of the ROD. For example, the SWQC for VC changed from 3.3 ug/L to 7.6 ug/L, and for benzene from 38 ug/L to 114 ug/L.

4.3 The Additional Administrative Controls

The documents reviewed in the preceding sections indicate that the majority of the health risks at the site are associated with the potential for human exposure to ground water. The importance for the ground water exposure pathway is the same for the no-action as well as the pump and treat remedial alternatives. In both of these cases some ground water contamination will migrate toward Lake Bemidji.

The ground water exposure pathway would be eliminated by additional institutional controls requiring abandonment of all wells potentially impacted by the plume. Currently, this area includes all wells covered by the MDH well advisory west of Tamarack Avenue. Well abandonment would be mandated in the well advisory area east of Tamarack Avenue based on the plume movement as defined by the monitoring well network. Rigorous enforcement of the MDH well advisory, in addition to the above requirements, by the local or state regulatory agencies, and a thorough assessment of the plume location and contaminant concentrations over time will be protective of the public health. Plume monitoring will also be valuable to ensure that the ARARs for SWQC are met when the plume discharges to Lake Bemidji.

4.4 Additional Exposure Pathways

The above discussion has focused on the difference of human health risks to VOCs due to elimination of the ground water exposure pathway. The key exposure routes identified in the Administrative Order are "direct contact with and drinking of the water and inhalation of airborne contaminants emanating from the on-site gas vents." The risks associated with on-site gas vents for the landfill can not be evaluated at present due to the absence of any monitoring data. However, these risks are not affected by the selection of ground water remedial alternative.

The no further action alternative was described in the ROD in terms of its ability to meet the SWQC for the discharge of contaminated ground water to Lake Bemidji. Based on the results of the numerical computer ground water modelling, it was estimated that the plume would reach Lake Bemidji in 34 years at concentrations below the SWQC. Thus the impact of the plume on the lake was not the basis for rejecting the no action alternative. The exceedance of the contaminant concentrations above MCLs was the reason for using an active remediation strategy.

4.5 Summary

The most significant known risks are due to potential exposures to ground water contaminated with VC. These risks can be eliminated by ensuring that the impacted ground water is not available for use.

Assuming that human exposures to ground water are eliminated, the ARARs for the site should be the SWQC for Lake Bemidji. As stated in the ROD, it is unlikely that these would be exceeded under a no-action alternative.

To eliminate the potential for human exposure to contaminated ground water, additional institutional controls should be put in place to abandon all wells west of Tamarack Avenue in the well advisory. The local governmental bodies and MDH must enforce this well abandonment program.

The well advisory must move and change as the plume monitoring indicates that the contaminant front is migrating to the east.

5.0 PROPOSED RESPONSE ACTION

5.1 Introduction

Given the previous discussions regarding review of Alternative 3 and the health risk assessment, Alternative 1 - plume monitoring will be reevaluated as a viable alternative. Also, a bioremediation alternative will be evaluated and compared to the nine criteria of the NCP and to Alternatives 1 and 3.

5.2 Reassessment of Alternative 1 - Plume Monitoring

The FS analyses of Alternative 1 pursuant to the nine NCP evaluation criteria is provided in Section 4.2.1 of the FS (pages 4-2 through 4-4). This discussion parallels and modifies that assessment.

5.2.1 Description

The no-action alternative actually assumes action in the form of long-term (30 year) monitoring and institutional control of exposure to ground water posing health risks. Therefore, it is better described as a "plume monitoring alternative." The proposal for long-term monitoring is adequate with the addition of some analytical parameters. To assess the potential for, and effects of, natural biodegradation, the parameter list under the long-term monitoring plan should include dissolved oxygen, nitrate and ammonium nitrogen, total and reactive phosphorous, and alkalinity if these parameters are not part of the "conventional water quality parameters" proposed for analysis in the FS (page 4-2). The addition of these parameters would cost less than $100 per sampling event and would, therefore, not significantly change the estimated costs of the alternative.

5.2.2 Assessment

Overall Protection of Human Health and the Environment

The most significant issue for this threshold evaluation criterion is control of private ground water use downgradient of the landfill. The MP FS contemplated a long-term well drilling advisory, under MDH authority, which would at least prohibit installation of new private supply wells by drillers licensed by the MDH. Additionally, the local responsible governmental units have recently indicated that any present private well use for potable supply will be terminated. Remaining private well users will be converted to the municipal supply system. That level of institutional control will eliminate exposure to impacted ground water and therefore provides certainty of human health protection.

Compliances with ARARs

The FS analysis of this criterion is adequate (see FS, Page 4-3). Plume monitoring will comply with MPCA municipal waste facility ground water standards.

Long-Term Effectiveness

In addition to the beneficial effects of a landfill cover as identified in the FS, the natural attenuation processes, including biodegradation, will add to the long-term effectiveness of plume monitoring.

Reduction of Toxicity, Mobility, or Volume

Again, long-term monitoring will be used to assess effects of natural biodegradation including the possibilities of increase or reduction of concentrations for parameters of concern.

Short-Term Effectiveness

Institutional controls (well advisory and municipal connection) will be sufficient to eliminate exposure to impacted ground water. These controls are in place.

Implementability

Plume monitoring is implementable.

Cost

The FS estimates the present value cost of Alternative I to be $300,000. The annual maintenance and monitoring costs are estimated to be $24,000. The addition of the analytical parameters specified in Section 4.3.1 Description (above) will increase sampling analysis costs by less than $200 per year. This additional cost does not significantly alter the present value or annual costs estimated in the FS. However, incorporating inflation, the present value cost of this alternative is approximately $516,000 (Appendix B).

Support Agency Acceptance

This report is submitted under the assumption that the EPA and MPCA will consider implementation of any NCP - compliant alternative even though a ROD and CERCLA Section 106 order have been issued by the EPA.

Community Acceptance

The FS states that the community "may not favor" the no-action alternative (page 4-4). Since publication of the FS in July 1990 there has been significant community awareness and evaluation of the proposed remedial alternatives and their associated costs. Based on the results of the most recent Bemidji City Council meeting and public hearing on August 26, 1991, the community is in favor of the long-term monitoring (no-action) alternative.

5.3 Assessment of Proposed Alternative 4 - Bioremediation Air Sparging/Soil Vapor Extraction

This alternative of air sparging/soil vapor extraction and bioremediation (labeled Alternative 4) is presented as a cost effective, reliable remedy compliant with the NCP nine criteria. This remedy is proposed for implementation in the event plume monitoring indicates the contaminant levels that would reach Lake Bemidji would be in excess of the SWQC. A treatability study is recommended to evaluate the requirement and at what level nutrient additions may be needed to sustain a level of biological activity to break down the organic contaminants.

The Kummer Landfill site ground water exhibits characteristic contamination associated with sanitary/industrial landfills. Organic contaminants of concern identified in ground water analysis are PCE, TCE, t-DCE, VC, and benzene. The only inorganic contaminant of concern in the ground water is barium. Of the organic contaminants noted at this site, state-of-the-art research and field experience has identified biological processes that can impact all of the contaminants at the Kummer Landfill site. Inorganic concentrations of barium are not excessive, and likely would not inhibit biodegradation of the organic contaminant.

5.3 Background

Water table aquifers are commonly polluted with chlorinated organic solvents such as TCE (References 1 and 2). The presence of oxygen alone in ground water contaminated by chlorinated solvents does not allow sufficient enrichment of native in-situ populations of microorganisms that are capable of producing enzymes to promote significant biodegradation of the contamination. Chlorinated solvents are biodegradable when a combination of oxygen with methane, propane, or natural gas is provided (References 3 through 10). Not only is TCE able to be co-oxidized with the presence of other carbon sources such as methane, propane, or butane, but a variety of other halogenated organic compounds are biodegradable under these conditions including t-DCE and vinyl chloride (Reference 11). In this study specific methane-utilizing bacteria degraded VC, t-DCE, 1,1-dichloroethene (DCE), and cis-1,2-dichloroethene (c-DCE). In situ applications of ground water treatment are possible using the co-oxidation of chlorinated solvents with the primary carbon source of methane.

Gaseous carbon sources such as methane, propane, or butane can be economically utilized to promote co-oxidation of chlorinated solvents because the gases are nontoxic, relatively inexpensive, and widely available in different forms including off-gas from landfills. Certain precautions are used in handling compounds such as methane to minimize explosion hazards under current engineering safety practices. The most limiting constraint with a water delivery system is the relatively low solubility of methane and oxygen in water. In a field evaluation conducted by Stanford University, Semprini and co-workers were successful in biostimulating a test zone by injecting methane- and oxygen-containing ground water in alternating pulses under induced gradient conditions (Reference 12). Direct evidence for biotransformation of VC, t-DCE, c-DCE, and TCE was obtained in this evaluation, while in the absence of biostimulation approximately 95 percent of the chlorinated solvents remained demonstrating negligible non-biological removal of the contaminants.

Benzene has been demonstrated to be widely biodegraded (References 13 through 18). Both passive in-situ ground water conditions and engineered systems that are designed to provide oxygen and inorganic nutrients to native populations of bacteria in the subsurface have been successful in promoting biodegradation of benzene.

In contrast, PCE is usually not biodegraded except under anaerobic conditions of little or no oxygen (References 19 through 24). While it is accurate to state that aerobic biodegradation will have little or no impact on PCE removal from ground water, an engineered in-situ treatment system could effectively provide separate zones of biological activity, either aerobic or anaerobic, by creating specific treatment areas employing biological degradation. Pulsing of amendments such as oxygen, methane, or gaseous nutrients that stimulate biodegradation processes is possible with the ground water sparging system.

Complementary removal of chlorinated solvents by volatilization and vapor extraction will assist biodegradation in the case that ground water contaminants are not reduced to adequately low levels or not sufficiently treated by biodegradation such as in the case for PCE. The air sparging portion of the treatment system will volatilize the residual ground water organic contamination, and the soil vapor extraction will remove the resulting vapors from vadose zone soils.

5.4 Biodegradation

Technical developments in the area of biodegradation during the past few years warrant a closer study of the potential for biodegrading organic constituents in the Kummer Landfill ground water. Therefore, if active remediation of the organic contaminants is required, a treatability study of Alternative 4 is discussed. For example, air-methane-nutrient sparging into ground water coupled with vapor extraction of vadose zones soils is a viable option for in-situ treatment that does not require installing and operating a ground water pump and treat system. Subsurface geological problems are minimized with this approach since the carrier media is not water, but instead gaseous forms of nutrients and carbon. Transport limitations for the gaseous carrier of dissolved oxygen or nutrient solutions are much less restricted than for a water carrier. The treatment system will aggressively attack contamination in defined areas that will act as a biological-physical barrier to the transport of contaminants downgradient.

5.4.1 Biodegradation Laboratory Bench-Scale Testing

The biodegradation potential for organic contaminants needs to be assessed in laboratory evaluations designed to mimic conditions in the ground water at the Kummer Landfill Site. Separate microcosms will be set up in bench-scale testing to evaluate biodegradation removal rates and the ending contaminant concentration after defined periods of sample incubation. Biological processes need to be assessed to determine each treatment condition efficacy under different sets of environmental conditions. Nutrients such as oxygen, nitrogen, phosphorus, and other trace elements will be added in different treatments to provide information for optimizing biodegradation rates and final concentrations after treatment. Biodegradation rates with respect to in-situ ground water temperature needs to be assessed. Other carbon sources to promote co-oxidation of chlorinated solvents are assessed by adding methane, propane, or butane as the primary carbon source. Populations of bacteria targeting specific ground water contaminants can be monitored to observe whether increased growth is occurring due to amended environmental conditions in the microcosms.

In order to determine whether biodegradation is a viable treatment option, a microcosm study is set up using aquifer samples containing representative contamination. U.S. Environmental Protection Agency guidance has recently advocated "exploring and promoting more effective and less costly technologies to solve the considerable problems" of environmental clean up of Superfund sites (Appendix C). The June 1991 memorandum states that "innovative treatment technologies should be routinely considered as an option in engineering studies where treatment is appropriate". While the Kummer Landfill may not require active treatment, and monitoring may suffice, the opportunity to assess the biodegradation potential should be used. Innovative treatment technologies "should not be eliminated from consideration solely because of uncertainties in their performance and cost."

The initiatives established with the EPA guidance "encourages EPA regions to fund treatability studies and engineering analyses for promising treatment technologies that might otherwise be considered unproven by the PRPs and too early in the development process". In addition, with EPA regional cooperation, "PRPs and owners/operators may sign cooperative agreements with EPA for services to support innovative technology treatability or pilot studies". Bioremediation certainly is an innovative technology falling within this guidance.

Actual costs to prepare an appropriate Biodegradation Treatability Work Plan and a Quality Assurance Project Plan (QAPP) are estimated at $25,000. A preliminary estimate of cost to conduct the treatability by the U.S. EPA R.S. Kerr Environmental Laboratory in Ada, Oklahoma, is $100,000. EPA's cooperation and involvement will ensure credible testing and evaluation of biodegradation for the ground water contaminants at the Kummer Landfill. Undoubtedly, the information generated will be useful for many other similar situations involving landfill ground water contamination.

The expected duration of biodegradation treatability testing is 6 to 12 months including all work plan and QAPP preparations, laboratory testing, and a summary report of findings. The summary report would provide site-specific information detailing biodegradation effectiveness under identical and altered environmental conditions for samples from the Kummer Landfill site.

5.4.2 Pilot-Scale Field Verification of Biodegradation

Following completion of the laboratory testing, field tests would assess site-specific considerations of soil heterogeneity and in-situ environmental conditions. The pilot-scale field evaluation would be set up in conjunction with pilot testing of air sparging and soil vapor extraction. The pilot-scale study construction is a segment of the larger full-scale system. For biodegradation testing, the pilot study would serve to identify whether amendments including methane and nutrients provide increased contaminant removal in the field setting, and help to firmly establish economics of operating the biological system in conjunction with volatilization and vapor extraction. Designs can be easily modified during this phase to optimize the effectiveness of full-scale installation, operation, and performance.

5.5 Volatilization and Vapor Extraction

In-situ biodegradation has been successfully combined with other treatment processes to reduce organic contaminants in aquifers. Air sparging has been used as a method to deliver dissolved oxygen into ground water, and in other cases, promote volatilization of trapped contaminants sorbed to soils.

An innovative ground water soil remediation system consisting of horizontal wells for injection of air and removal of vapors by vacuum extraction has been demonstrated at the U.S. Department of Energy's Savannah River Site in South Carolina (Reference 25). The system was designed to concurrently remediate unsaturated zone soils and ground water containing PCE and TCE contamination. Initial levels of TCE at 1,600 and 1,800 ug/L in two wells showed changes to 10 and 30 ug/L, respectively, in a 20 week test. Test results indicated that the extraction rate of VOCs was increased by approximately 20 percent by the injection of air below the water table coupled with soil vapor extraction. A significant mass of VOCs was removed from the ground water during the air injection phase as demonstrated by mapping the TCE concentrations in the ground water over time.

Other experiences with air sparging and vapor extraction have produced reductions of chlorinated solvents in ground water down to concentrations as low as non-detectable (<10 ug/L) for TCE in periods as short as two months (References 26 and 27).

5.5.1 Volatilization and Vapor Extraction Pilot Testing

The efficacy of air sparging to promote volatilization and vapor extraction is best assessed under site-specific field conditions. Since a pilot-scale system is just one-seventh of the planned full-scale system, capital costs are minimized in gaining design criteria information of air sparging well spacing and depth, and the effective radius of influence for soil vapor recovery. The simplicity of the design for air sparging-soil vapor extraction

(AS-SVE) allows for easy modification of the installation during this phase of testing. The optimal design configuration can be derived, and full-scale implementation will consist of several identical sub-units, each separately operated and controlled to address site-specific conditions of ground water depth and geological conditions.

5.5.2 Full-Scale Installation of Air Sparging-Soil Vapor Extraction

From the pilot-scale testing, full-scale implementation will proceed with fine-tuning of the individual sub-unit area AS-SVE system. Integrated use of wells for air sparging and soil vapor extraction would maximize effectiveness of the well system, both in cost and system performance. As the site remediation proceeds, modifications can be easily implemented with adjustments to air flows, both in the sparging and in the vapor extraction.

5.6 Integrated System Operation

Based on the results from bench-scale and pilot-scale testing of biodegradation coupled with field pilot testing of AS-SVE, the complete system would be engineered to deliver optimal contribution toward contaminant removal from the ground water. Again, all the prior testing would have established the effectiveness of amendments for biodegradation in conjunction with operation of the AS-SVE system.

5.7 Bioremediation-Air Sparging-Soil Vapor Extraction Alternative Analysis

Description: Ground water would be treated in situ by a system employing biodegradation of organics, air sparging to promote volatilization of organics, and vapor extraction of produced vapors. The In Situ Biofilter Curtain will intercept ground water flow downgradient the landfill site. The interception zone would be located approximately 100 feet downgradient the landfill. The interception zone would run approximately 1,500 feet cross gradient.

Biodegradation would be stimulated by oxygen introduction via atmospheric air introduction, and possibly pulsing of air/methane/gaseous inorganic nutrients during an alternating cycle of ground water sparging. Cycling timers/solenoids will operate for 15 minutes per hour in each air sparging well. Typical air sparging wells will be screened 15 to 30 feet below the water table with the outer casing screened for 5 to 10 feet as a vertical vapor extraction point. Soil vapor extraction will operate continuously.

Assessment: Evaluation of the proposed remedy to the NCP evaluation criteria.

Overall Protection of Human Health and the Environment:

The proposed alternative will be protective of human health and the environment as contaminated ground water is treated in situ to meet MCLs.

Compliance with ARARs:

The proposed remedy complies with Minnesota standards for ground water quality at the compliance boundary of mixed municipal solid waste landfills and can meet drinking water MCLs for the aquifer and with air quality objectives and criteria. The remedy is consistent with EPA ground water protection strategy.

Long-Term Effectiveness:

Treatment process combining biodegradation, volatilization, and vapor extraction would capture and treat ground water contamination in situ. Ground water moving downgradient would be protected from future contamination. Organic contamination of concern would be completely removed from the ground water by the combination of biodegradation, volatilization, and vapor extraction. The alternative treats the contamination in situ, therefore, there is no removal of inorganic contamination to the surface, no sludge generation, and no landfill disposal of contaminated treatment by products required.

Reduction of Toxicity, Mobility, or Volume:

This alternative would reduce contaminant in the entire contaminant plume as it moves past the east landfill boundary. The proposed treatment system for organic removal would reduce the toxicity and volume of the contaminated ground water.

Short-Term Effectiveness:

Biodegradation and vapor extraction have been demonstrated to cause significant reductions in contaminant mass in a time frame of months.

Implementability:

Minimal risk to the community during well development and treatment of contaminated in-situ ground water. Possible risk to workers during air sparging-vapor extraction well development and vapor extraction discharge due to VOC emissions. Requires air monitoring and possible respiratory protection. Safety training and appropriate explosion-proof equipment needed for methane storage, handling, and treatment usage. Requires no protective equipment and no spill response training since there is no above-ground treatment in the system. Technically feasible and flexible in design modifications. Inexpensive injection well design for introduction of air/methane pulses has dual purpose of providing vapor extraction vertical points through the use of the outer casing screened in the vadose zone. Easily monitored by sampling discharge from gas survey points and vapor extraction discharge for CO_2, O_2, and contaminants of concern. Monitoring wells are sampled for dissolved oxygen and contaminants of concern. System operation monitored by pressure/vacuum gauge measurements. The level of biodegradation can be obtained through bench-scale microcosm studies for benzene, PCE, and other chlorinated contaminants of concern. System design can be assessed and modified in a pilot-scale evaluation in the field. The pilot-scale is actually one-seventh of the total system. Capital costs are not increased by the pilot-scale testing as it would become part of the full-scale system. Biodegradation, volatilization, and vapor extraction system designs are flexible to meet site-specific design needs. Modifications over the duration of the treatment can be easily implemented. Permit may be necessary for air discharge. Services and materials to construct and implement Alternative 4 are available.

Cost:

The present value cost based on 30 years of operation of the proposed treatment system is $1,340,000 assuming a ten percent discount rate and $2,000,000 at a four percent discount rate. The annual O & M costs are estimated to be $100,000. The capital cost to implement the alternative is $500,000. A $100,000 treatability study is included in the capital costs to evaluate the level of nutrients required to effectively treat the contaminants.

Support Agency Acceptance:

The MPCA has indicated its support for a bioremediation alternative. The EPA in the ROD indicated its willingness to evaluate the feasibility of a bioremediation alternative.

Community Acceptance:

The community would likely favor in-situ ground water treatment without above-ground ground water treatment and discharge if remedial action in addition to plume monitoring is required.

6.0 RE-EVALUATION OF ALTERNATIVES COMPARISONS AND REMEDY SELECTION

Three alternative response actions are compared here: plume monitoring (FS Alternative 1), pump and treat (FS Alternative 3), and previously discussed air sparging /soil vapor extraction (SVE) with contingent bioremediation (Alternative 4). FS Alternative 2 is not analyzed since it was determined to be less preferable than FS Alternative 3 in the ROD and since its attributes are sufficiently similar to FS Alternative 3 which is included here.

The basis for alternative comparison are the nine criteria set forth in the NCP, subparts 300.430 (e)(9)(iii)(A)-(I). NCP compliance, to the extent practicable, is required pursuant to CERCLA Section 121(a). A comparison of FS Alternatives 1, 2, and 3 was performed in the MP FS (pp. 4-9 through 4-11) and the ROD (pp. 12-15). The comparison which follows in Section 6.1 builds upon and modifies the alternative comparisons in the FS and ROD based on the addition of bioremediation Alternative 4, the criticisms of Alternative 3 as presented in Section 3.0 of this report, and events which have occurred since publication of the FS and ROD.

Once the Comparison of Alternatives has been performed, the remedy selection process requires a weighing of the nine criteria pursuant to the NCP subpart 300.430(f)(i). The first two criteria -- overall protection of human health and the environment and compliance with ARARs (unless a specific ARAR is waived) -- are threshold requirements that each alternative must meet in order to be eligible for selection. The next five criteria are termed "primary balancing criteria" and are significant to the remedy selection but are not threshold requirements. The last two criteria -- state and community acceptance -- are termed "modifying criteria that shall be considered in remedy selection" (NCP, subpart 300.430(f)).

The selected remedy must be "cost-effective" pursuant to NCP subpart 300.430(f)(1)(ii)(D). A remedy is considered cost-effective if "its costs are proportional to its overall effectiveness." The ROD must describe "how the remedy is cost-effective, i.e., explaining how the remedy provides overall effectiveness proportional to its costs" pursuant to NCP subpart 300.430(f)(5)(ii)(D).

The ROD (pp. 18-23) contains a section entitled, "X. STATUTORY DETERMINATION" which addresses the selected alternative -- Alternative 3 -- according to the NCP selection process outlined above. That selection process is re-analyzed in Section 6.2 below based upon the introduction of the new remedy, the criticisms of Alternative 3 contained in Section 3.0 and other developments subsequent to ROD publication.

6.1 Comparison Among Alternatives

6.1.1 Overall Protection of Human Health and the Environment

The ROD identifies Alternative 1 as not protective of human health and the environment. The basis was stated to be the nonenforceable nature of the institutional control of use of contaminated ground water. Since ROD publication, the local responsible governmental units have indicated that private ground water use will be terminated and any present private users will be connected to the municipal system. The establishment of a well advisory area pursuant to MDH authority can prevent future use of contaminated ground water. Therefore, institutional control associated with Alternative 1 can effectively eliminate exposure and Alternative 1 is protective of human health.

The same institutional controls are, in fact, necessary under any of the proposed alternatives. Alternative 3 does not capture the entire plume. Thus, those areas downgradient of the area of containment require the same institutional controls. Within the Alternative 3 containment areas, institutional controls to prevent exposure will be required for decades based on past nationwide experience with pump and treat ineffectiveness to attain ARARs (see Section 3.2 above). Thus, any doubt regarding the enforceability of institutional controls detracts from the effectiveness of human health protection for all proposed remedies.

Alternative 4, in conjunction with institutional controls, offers the greatest degree of human health protection since it addresses mass reduction for the entire plume, possibly to MCL levels. It is more protective than Alternatives 1 and 3 because those alternatives allow all, or part, of the existing plume to migrate downgradient and to eventually discharge to Lake Bemidji.

Regarding protection of the environment, Alternative 4 is most protective because it allows the least amount of further plume migration and will result in lowest concentration discharge to Lake Bemidji. Between Alternatives 1 and 3, Alternative 3 is more protective in the sense that the total mass of contaminants downgradient of the capture area will be lower than for Alternative 1. Thus, the duration of plume discharge to Lake Bemidji should be less for Alternative 3 than for Alternative 1. However, the FS (Appendix C, pages 17 through 20) concludes that both Alternatives 1 and 3 will not produce surface water quality discharge criteria violations.

Therefore, Alternatives 1, 3, and 4 all offer adequate protection of human health and the environment. This threshold criterion is satisfied. However, with the uncertainty of the production of a hazardous sludge in Alternative 3, this alternative may violate this criterion.

6.1.2 ARARs Compliance

The key ARAR compliance issue is attainment of MCLs within the aquifer. In that regard, it is most important to note that only Alternative 4 offers the possibility of maintaining MCLs downgradient of the zone of management. None of the alternatives offer permanent, total aquifer restoration within a short time frame (i.e., within ten years). But all of the alternatives will theoretically attain MCL restoration within some period of time following cessation of landfill source behavior. Restoration to MCLs will require a time frame of centuries or millennia.

The ROD presumption that Alternative 3 can comply with ARARs within ten years is in direct contradiction to the literature review findings presented in Section 3.2 regarding the effectiveness of pump and treat to attain ARARs. Further, the uncaptured plume portion in Alternative 3 cannot accurately be predicted to reach MCLs in a ten year time frame given the state of the science of transport quantification. It is possible that after ten years of pumping, the extraction well effluent concentrations will decrease to levels near the MCLs. However, the continuing source behavior of the landfill and the other physical and chemical processes defined in Section 3.2 above will act to cause very long term contaminant levels above MCLs based on experience at many other CERCLA sites. Thus, Alternative 3 does not offer ARAR compliance within ten years.

The ROD inconsistently and unjustifiably identifies Alternative 1 as not compliant with ARARs (see ROD, page 13). The particular ARARs cited are restoration to MCLs and attainment of Minnesota Ground Water Protection Act (GWPA) and Minnesota Rule 7060 requirements. Regarding MCL compliance, the ROD states that Alternative 1 requires 80 years to attain MCLs. Again, referring to the above discussion and more specifically addressed in Section 3.2 herein, there are significant, credible and numerous technical literature sources which indicate Alternative 3 cannot achieve MCLs in any shorter time frame. Regarding the GWPA and Rule 7060, the ROD later identifies these potential ARARs as not applicable. Even if they were ARARs, none of the proposed alternatives can produce cessation of ground water degradation caused by further releases from the landfill -- a feat which is not technically feasible at this site. The alternatives differ only in the area of aquifer impacted and the overall amount of mass which will be present in the aquifer over the long term.

Therefore, all three alternatives -- 1, 3, and 4 -- offer ARAR compliance although total and permanent MCL restoration is expected to require decades or centuries. Alternative 4 likely offers MCL maintenance for the area downgradient of the management zone, whereas Alternatives 1 and 3 allow further downgradient migration. In addition, the potentially hazardous sludge produced by Alternative 3 may violate an ARAR.

6.1.3 Long Term Effectiveness and Permanence

The ROD screened Alternative 1 out of the selection process based on the prior two threshold criteria and, therefore, Alternative 1 was not evaluated for the present, or remaining, criteria in the ROD.

The premise of effectiveness and permanence is that remedies can be proposed which effectively remove all contaminant mass from the environment, permanently. Because none of the alternatives can cause faster release of contaminants from the source landfill, none of them can effectively remove all mass, permanently, in a short time frame (i.e., on the order of ten years). Alternatives 3 and 4 can reduce the mass in a short time frame once it has entered the aquifer. For the very long term, however, any of the alternatives are effective at protection human health and the environment; the key being the associated institutional control. If the landfill ever ceases source behavior, each alternative has an associated additional time increment before permanent mass removal is achieved. That additional time increment is shorter for Alternative 4 (possibly a decade or less) and longer for Alternative 3 (decades to centuries for pump and treat) and Alternative 1 (decades to centuries for plume discharge to Lake Bemidji).

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Volume reduction in the form of contaminant mass removal or transformation is greatest for Alternative 4 since it addresses reduction of contaminant mass in the entire plume. Alternative 3 contains only a portion of the plume, thus reducing toxicity and volume of contaminated ground water only for the contained area. Alternative 1 offers least reduction of total mass, but naturally provides attenuation through dispersion, volatilization, and natural biodegradation. These attenuation mechanisms collectively reduce the toxicity of a given volume of contaminated ground water.

Alternative 3 produces a sludge which requires off-site disposal raising potential concerns regarding impacts on environmental media due to ultimate disposal. The result is mass transfer to the sludge rather than true and permanent reduction of the mass volume.

6.1.5 Short Term Effectiveness

As stated above, there are no practicable remedies which can permanently meet restoration ARARs and protect health and the environment in a time frame of years. The action which provides the most significant short-term effectiveness toward meeting the latter criterion is institutional controls which are necessary in all three alternatives. Regarding short-term effectiveness in meeting the former criterion (ARAR/MCL attainment), Alternative 4 offers the greatest potential for maintaining MCLs downgradient both in the short and long term. Alternative 3 offers greater short term mass removal than Alternative 1. However, Alternatives 1 and 3 offer the same degree of short-term downgradient protection due to institutional controls.

6.1.6 Implementability

Alternative 1 is, essentially, presently implemented. Alternative 3 would require one construction season for implementation. Alternative 4 is expected to be implementable within two years.

Alternative 4 represents innovative technology. For this reason, the two-year implementation time frame has been established to accommodate necessary field testing and design procedures. The technology has been proven implementable and effective at other sites. The engineering requirements are of no greater complexity than for Alternative 3. Alternative 4 requires installation of sparging, SVE, and nutrient introduction points further downgradient than the containment wells proposed in Alternative 3. Alternative 4 may, therefore, require greater administrative efforts to properly address access to those downgradient areas.

6.1.7 Costs

The ROD and FS compare costs using present worth estimates which assume a 10 percent discount rate. That rate is unrealistically high for any alternative duration, and especially for a 30-year period. The present worth costs have been recalculated assuming a more realistic 4 percent discount rate. The 10 percent discount unrealistically causes greater reduction of the present worth of annual operation and maintenance (O & M) costs. The cost comparisons are provided in Table 4 for the case of a 10 percent discount rate and in Table 5 for the case of the 4 percent discount rate.

6.1.8 State Acceptance

The MPCA is signatory to the ROD which selects Alternative 3. The ROD also acknowledges the MPCA's eagerness to evaluate a bioremediation remedy such as Alternative 4. Alternative 1 also merits consideration since it is identified as NCP compliant based on the re-evaluation presented here.

6.1.9 Community Acceptance

The FS indicates a prejudgment of community non-acceptance of Alternative 1 (see FS, pp. 4-4, 4-6, and Table 4-4). The ROD states only that the "public generally accepted ground water extraction..." (ROD, page 15). Since issuance of the ROD, the public acceptance seems stronger for Alternative 1 than Alternative 3. The recent August 26, 1991, public meeting evidenced a community sentiment strongly favoring Alternative 1.

6.2 Remedy Selection

The ROD selects Alternative 3 and discusses the virtues of only that alternative (see ROD, pp. 15-18). That selection evaluation is not complete for two reasons. First, the NCP requires a justification of the remedy selection based on the weighing scheme for the nine evaluation criteria. The ROD addresses only the first two criteria and cost-effectiveness (implicitly the seventh criterion). Secondly, the ROD does not carry forward Alternative 1 (because that alternative was eliminated as not meeting criteria 1 and 2) nor does it compare Alternative 3 to Alternative 4 under the weighing scheme (because Alternative 4 was not proposed in the FS).

This section presents a re-evaluation of the remedy selection justification and concludes that Alternative 1 is the preferred alternative followed by Alternative 4 and then Alternative 3. The basis for this ordering of alternatives has mostly been provided in the preceding Comparison of Alternatives section. As stated there, all three alternatives meet the threshold requirements of protecting human health and the environment and eventually attaining restoration ARARs. Based upon the more subtle issues of relative expediency of ARAR compliance and amount of uncontrolled mass in the aquifer, Alternative 4 is most desirable followed by Alternative 3 and then Alternative 1. The key differences with the FS and ROD alternatives comparisons are (1) that institutional controls can be effectively implemented (making Alternative 1 a viable alternative) and, in fact, are necessary for all alternatives; and (2) that Alternative 3 will not attain ARARs on a time scale anywhere near ten years (neither within nor outside the Alternative 3 containment area).

Regarding the five balancing criteria, Alternative 4 is more desirable with respect to long- and short-term effectiveness and reduction of toxicity and volume, followed by Alternative 3 then Alternative 1. However, none of the three alternatives clearly emerge as fatal or obviously superior based on those three criteria. Regarding implementability, any of the three alternatives are implementable in a short time frame (i.e., less than two years). Alternative 1 is most easily implemented and is presently in effect. Alternative 4 may be slightly more difficult to implement than Alternative 3 due to the larger area needed for remedial operations. Simple costs comparison indicates that Alternative 1 is far less costly than Alternative 4 (by a factor of four) and that Alternative 4 is two to five times less costly than Alternative 3 (Tables 4 and 5). The 30-year present worth cost figures indicate at least a two million dollar difference between Alternative 4 and Alternative 3. This cost disparity grows when a more realistic discount rate such as 4 percent is utilized in the present worth calculations.

The final two "modifying criteria" are state acceptance and community acceptance. The MPCA has indicated a willingness to consider at least a bioremediation alternative (ROD, p. 15). The ROD allows for amendment if it is shown that bioremediation is equally protective of human health and the environment as Alternative 3 (ROD, p. 23). This report has demonstrated that to be the case. Further, this report has identified Alternative 1 as being NCP compliant. Therefore, both Alternative 1 and Alternative 4 should be considered for selection. The community has indicated acceptance of, and a preference for, Alternative 1.

The very important and NCP- and CERCLA-mandated requirement of cost-effectiveness is given brief attention in the ROD. The ROD acknowledges that Alternative 3 "is not the most cost effective" (ROD, page 22). Further, Alternative 1 was not compared to Alternative 3 based on cost-effectiveness because Alternative 1 was eliminated from the viable alternatives based on the ROD assessment of the threshold criteria.

As established here, Alternative 1 and Alternative 4 are viable, NCP compliant alternatives. Based on the three-tiered weighing analysis, Alternative 4 would appear to be most effective. Alternative 1 and Alternative 3 are of lesser overall effectiveness with Alternative 3 offering only greater mass removal for a part of the plume as compared to Alternative 1. But the NCP requires costs to be proportional to overall effectiveness. Based on that requirement, Alternative 1 is most cost-effective. The cost of Alternative 3 is at least an order of magnitude higher. Yet Alternative 3 offers more effectiveness due only to greater short term mass removal. Both Alternatives 1 and 3 leave the downgradient area unusable for potable supply for several decades. However, the use of this shallow aquifer for potable supply in that area is not desirable even without the landfill contamination. The aquifer has already demonstrated its susceptibility to surface manmade effects. Other manmade effects will likely be manifested which will impact potability. These effects include road salting and lawn chemicals. The key to the effectiveness of Alternatives 1 and 3 to protect human health lies in the institutional controls, independent of whether large quantities of water are extracted. Both alternatives are expected to meet ARARs for aquifer discharge to Lake Bemidji. Therefore, Alternative 1 is more cost-effective than Alternative 3.

The cost-effectiveness comparison between Alternative 1 and Alternative 4 raises similar issues. Again, the primary action providing health protection is the institutional control which is necessary for any of the alternatives. Alternative 4 does offer likely maintenance of MCL levels downgradient of the plume management area. But the associated cost is at least four times greater than, and at least one million dollars more than, that for Alternative 1. Therefore, Alternative 4 is less cost-effective than Alternative 1, especially given the susceptibility of the aquifer to other anthropogenic effects.

The ROD lastly addresses the preferences for permanent solutions and treatment remedies. Permanence cannot be achieved under any of the proposed alternatives for at least the time period during which the landfill releases contaminants plus some additional time period for withdrawal (Alternative 3), volatilization or degradation (Alternative 4), or discharge to Lake Bemidji (Alternative 1). All of these time frames are on the order of at least several decades. The preference for treatment favors Alternative 3. But that alternative has associated sludge and GAC disposal which simply transfers the contaminant to a medium and raises new environmental and health concerns regarding the disposal method. CERCLA also contains a preference for innovative technologies which include Alternative 4.

In conclusion, based on the foregoing re-evaluation of the comparison of alternatives and remedy selection requirements, Alternative 1 is the preferred alternative for the Kummer Sanitary Landfill site, followed by Alternative 4 and then Alternative 3.

7.0 RECOMMENDATIONS

Delta provides the following recommendations with regard to OU3 at the Kummer Sanitary Landfill:

- Alternative 1 - Plume Monitoring should be implemented.
- If additional ground water remediation is required, Alternative 4 - Bioremediation/Air Sparging/Soil Vapor Extraction should be assessed through the implementation of treatability study.

8.0 REMARKS

The recommendations contained in this report represent our professional opinions. These opinions are based on currently available information and are arrived at in accordance with currently accepted hydrogeologic and engineering practices at this time and location. Other than this, no warranty is implied or intended.

This report was prepared by **DELTA ENVIRONMENTAL CONSULTANTS, INC.**

Paul A Durkee
Paul A. Durkee
Project Manager

Date: 8/30/91

Mark J. Simonett
Mark J. Simonett
Senior Hydrogeologist

Date: 8-30-91

Michael M. Martinson
Michael M. Martinson
Senior Scientist
National Technical Advisor - Bioremediation

Date: 8-30-91

Reviewed by:

Paul R. Goudreault
Paul R. Goudreault
Senior Hydrogeologist
St. Paul District Office Manager

Date: 8/30/91

jms.830

<u>**References for Section 3.2**</u>

Abelson, P.H. 1990. Inefficient Remediation of Ground-Water Pollution. Science, v. 250, n. 4982, p. 733.

Brown, R.A., G.E. Hoag and R.D. Norris. 1988. The Remediation Game: Pump, Dig or Treat. Groundwater Quality Protection Pre-Conference Workshop Proceedings, 61st Annual Conference, Water Pollution Control Federation, Oct. 3, 1988.

Brown, S.M. 1990. Technology Improves Aquifer Remediation. Environmental Protection, Oct. 1990, pp. 29-33, 66, 70.

Campbell, G.E. 1990. Dense Non-Aqueous Phase Liquid Contamination of Ground Water, A Case History and Implications for Ground Water Remedial Action. Proceedings of the FOCUS Conference on Eastern Regional Ground Water Issues, Oct. 17-19, 1990.

Cherry, J.A. 1990. A Twenty-Five Point Synopsis of the DNAPL Paradigm and Implications, Revision No. 3, November 19, 1990, Prepared by John A. Cherry for Inclusion in Notes for the DNAPL Short Course, The University of Waterloo.

Doty, C.B. and C.C. Travis. 1991. The Effectiveness of Groundwater Pumping as a Restoration Technology. Oak Ridge National Laboratory, ORNL/TM-11866.

EPA. 1989a. Considerations in Ground Water Remediation at Superfund Sites. Memorandum by Jonathan Z. Cannon, Acting Assistant Administrator, Office of Solid Waste and Emergency Response, Directive No. 9355.4-03, Oct. 18, 1989.

EPA. 1989b. Evaluation of Ground-Water Extraction Remedies: Volume 1, Summary Report. EPA/540/2-89/054.

EPA. 1989c. Evaluation of Ground-Water Extraction Remedies: Volume 2, Case Studies 1-19. EPA/540/2-89/054b.

EPA. 1990. EPA Correction to December 1989 Focus Article on Pump and Treatment. Letter to editor by Bill Hanson, Chief, Remedial Operations and Guidance Branch. Hazardous Materials Control Research Institute, Mar. 1990.

EPA. 1991. Letter to editor by Henry L. Longest, II, Director, Office of Emergency and Remedial Response. Environmental Science and Technology, v. 25, n. 5.

Gass, T.E. 1991. National Research Council to Study Failure of "Pump and Treat" Systems. Ground Water, v. 29, n. 4, p. 628.

Ground Water Monitor. 1989. Extraction Systems Fail to Restore Ground Water, EPA Researcher Finds. v. 4, n. 25, p. 242

Haley, J.L., B. Hanson, C.G. Enfield and J.P. Glass. 1991. Evaluating the Effectiveness of Ground Water Extraction Systems. Ground Water Monitoring Review, Winter 1991.

Hall, C.W. 1988. Practical Limits to Pump and Treat Technology for Aquifer Remediation. Groundwater Quality Protection Pre-Conference Workshop Proceedings, 61st Annual Conference, Water Pollution Control Federation, Oct. 3, 1988.

Huling, S.G. and J.W. Weaver. 1991. Dense Nonaqueous Phase Liquids. EPA Ground Water Issue, EPA/540/4-91-002.

Hunt, J.R., N. Sitar and K.S. Udall. 1988. Nonaqueous Phase Liquid Transport and Cleanup: 1. Analysis of Mechanisms. Water Resources Research. v. 24, n. 8, pp. 1247-1258.

Keely, J.F. 1989. Performance Evaluations of Pump-and-Treat Remediations. EPA Ground Water Issue, EPA/540/4-89/005.

MacKay, D.M. and J.A. Cherry. 1989. Groundwater Contamination: Pump-and-Treat Remediation. Environmental Science & Technology, v. 23, n. 6, pp. 630-636.

Mercer, J.W. and R.M. Cohen. 1990. A Review of Immiscible Fluids in the Subsurface: Properties, Models, Characterization and Remediation. Journal of Contaminant Hydrology, v. 6, pp. 107-163.

Mercer, J.W., D.C. Skipp and D. Giffin. 1990. Basics of Pump-and-Treat Ground-Water Remediation Technology. Robert S. Kerr Environmental Research Laboratory, EPA-600/8-90/003.

Newell, C.J. and J.A. Connor. 1991. Assessment, Field Testing, and Conceptual Design for Managing Dense Non-Aqueous Phase Liquids (DNAPL) at a Superfund Site. Prepared for EPA DNAPL Workshop Proceedings, Apr. 16-18, 1991.

Newell, C.J., J.A. Connor, D.K. Wilson and T.E. McHugh. 1991. Impact of Dissolution of Dense Non-Aqueous Phase Liquids (DNAPLs) on Ground Water Restoration. Abstract of paper accepted at NWWA Petroleum Hydrocarbons Conference, Houston, Texas, Nov. 1991.

Nyer, E.K. 1990. One Small Voice for Pump-and-Treat. Ground Water Monitoring Review, Spring 1990, pp. 70-72.

Office of Technology Assessment. 1989. Coming Clean: Superfund's Problems Can be Solved. U.S. Government Printing Office, OTA-ITE-433, Oct. 1989.

Rowe, Jr., W.D. 1991. Superfund and Groundwater Remediation: Another Perspective. Environmental Science and Technology, v. 25, n. 3, pp. 370-371.

Schiffman, A. 1989. Cleanup of Polluted Groundwater -- A Solution in Search of the Right Problem. Ground Water Monitoring Review, v. 9, n. 1, pp. 5-8.

Stipp, D. 1991. Super Waste? Throwing Good Money at Bad Water Yields Scant Improvement in New Jersey Project. Wall Street Journal, May 15, 1991.

Superfund Report. 1990a. Groundwater -- Pump and Treat Method Flawed Says Report. Sept. 12, 1990, p. 7.

Superfund Report. 1990b. Contaminated Groundwater -- ARARS An Unrealistic Standard, Scientists Say. Oct. 24, 1990, p. 5.

Superfund Report. 1991a. Pump & Treat -- Critical Study May Prompt National Academy of Sciences Review. Jan. 2, 1991, p. 24.

Superfund Report. 1991b. Groundwater Cleanup -- Current Groundwater Guidelines may be Revised. Feb. 27, 1991, p. 20.

Superfund Report. 1991c. Groundwater Cleanup -- Scientists to Assess Flawed Treatment Method. Mar. 27, 1991, p. 22.

Superfund Report. 1991d. Remedy Selection -- EPA Taps Pump and Treat as Interim Fix. Apr. 10, 1991, p. 25.

Superfund Report. 1991e. Groundwater Remediation -- NAS to Analyze Pump and Treat Method. June 5, 1991, p. 6.

Superfund Report. 1991f. Pump and Treat -- Technology Ineffective for Restoration, Says DOE Report. July 17, 1991, p. 24.

Travis, C.C. and C.B. Doty. 1990. Can Contaminated Aquifers at Superfund Sites be Remediated? Environmental Science and Technology, v. 24, n. 10, pp. 1464-1466.

Tucker, W.A., M.W. Kemblowski and D.E. Draney. 1989. Technological Limits of Groundwater Remediation: A Statistical Evaluation Method. Proceedings of the Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention Detection and Restoration, Nov. 15-17, 1989.

References for Sections 5.3 through 5.8

1. Wilson, J.T. and McNabb, J.F., Biological transformation of organic pollutants in groundwater, EOS. 64, 505, 1983.

2. Wilson, J.T., Enfield, C.G., Dunlap, W.J., Cosby, R.L., Foster, D.A., and Basking, L.B., Transport and fate of selected organic pollutants in a sandy soil, J. Environ. Qual., 10, 501, 1981.

3. Wilson, J.T. and Wilson, B.H., Biotransformation of trichloroethylene in soil, Appl. Environ. Microbiol., 49, 242, 1985.

4. Fogel, M.M., Taddeo, A.R., and Fogel, S., Biodegradation of chlorinated ethenes by a methane-utilizing mixed culture, Appl. Environ. Microbiol., 51, 720, 1986.

5. Strand, S.E. and Shippert, L., Oxidation of chloroform in aerobic soil exposed to natural gas, Appl. Environ. Microbiol., 52, 203, 1986.

6. Henson, J.M., Cochran, J.W., and Wilson, J.T., Aerobic biodegradation of halogenated aliphatic hydroc[illegible], presented at the 6th Annu. Meet. Soc. Environ. Toxicol. Chem., St. Louis, Mo., November 1985, 100.

7. Henry, S.M. and Grbic-Galic, D., Aerobic degradation of trichloroethylene (TCE) by methylotrophs isolated from a contaminated aquifer, presented at the 86th Annu. Meet. Am. Soc. Microbiol., Washington, D.C., March 1986, Q-64.

8. Wilson, B.H. and White, M.V., A fixed-film bioreactor to treat trichloroethylene-laden waters from interdiction wells, in Proc. 6th Natl. Symp. and Exp. on Aquifer Restoration and Ground Water Monitoring, National Water Well Association, Columbus, Ohio, 1986.

9. U.S. Environmental Protection Agency, National primary drinking water regulations: volatile synthetic organic chemicals, Fed. Reg., 49, 24330, 1984.

10. Henson, J.M., Nichols, P.D., and Wilson, J.T., Degradation of halogenated aliphatic hydrocarbons by a biochemically defined microbial community, presented at the 86th Annu. Meet. Am. Soc. Microbiol., Washington, D.C., March 1986, Q-1.

11. Tsien, H.-C., Brusseau, G.A., Hanson, R.S., and Wackett, L.P., Biodegradation of trichloroethylene by Methylosinus trichosporium OB3b, Appl. Environ. Microbiol., 55, 3155, 1989.

12. Semprini, L., Roberts, P.V., Hopkins, G.D., and McCarty, P.L., A field evaluation of in-situ biodegradation of chlorinated ethenes: Part 2, Results of biostimulation and biotransformation experiments, Ground Water, 28, 715, 1990.

13. U.S. Environmental Protection Agency, Microbial decomposition of chlorinated aromatic compounds, EPA/600/2-86/090, 45, September 1986.

14. U.S. Environmental Protection Agency, Microbial degradation for pollutants in marine environments, EPA-600/9-79-012, 28, April 1979.

15. U.S. Environmental Protection Agency, Enhanced bioremediation utilizing hydrogen peroxide as a supplemental source of oxygen, EPA/600/2-90/006, 1, February 1990.

16. Higgins, I.J. and Burns, R.G., in The chemistry and microbiology of pollution, Chapter 4, Hydrocarbons, 111, 1975.

17. Ribbons, D.W. and Eaton, R.W., in Biodegradation and detoxification of environmental pollutants, Chapter 3, Chemical transformations of aromatic hydrocarbons that support the growth of microorganisms,60, 1982.

18. U.S. Environmental Protection Agency, Systems to accelerate in situ stabilization of waste deposits, EPA/540/2-86/002, 83, September 1986.

19. Fathepure, B.Z., Nengu, J.P., and Boyd, S.A., Anaerobic bacteria that dechlorinate perchloroethene, Appl. Environ, Microbiol., 53, 2671, 1987.

20. McCarty, P.L., Rittman, B.E., and Bouwer, E.J., in Groundwater pollution microbiology, Chapter 5, Microbiological processes affecting chemical transformations in groundwater, 105, 1984.

21. Wilson, J.T., Leach, I.E., Henson, M., and Jones, J.N., In situ biorestoration as a ground water remediation technique, Ground Water Monitor. Rev., 56, Fall 1986.

22. Freedman, D.L. and Gossett, J.M., Biological reductive dechlorination of tetrachloroethylene and trichloroethylene to ethylene under methanogenic conditions, Appl. Environ. Microbiol., 55, 2144, 1989.

23. Galli, R. and McCarty, P.L., Biotransformation of 1,1,1-trichloroethane, trichloromethane, and tetrachloromethane by a Clostridium sp., Appl. Environ. Microbiol., 55, 837, 1989.

24. Sulflita, J.M., Horowitz, A., Shelton, D.R., and Tiedje, J.M., Dehalogenation: A novel pathway for the anaerobic biodegradation of haloaromatic compounds, Science, 218, 1115, December 1982.

25. Kaback, D.S., Looney, B.B., Eddy, C.A., and Hazen, T.C., Innovative ground water and soil remediation: In situ air stripping using horizontal wells, in Proceedings of 5th Nat. Outdoor Action Conf., Las Vegas, Nevada, 47, 1991.

26. Middleton, A.C. and Hiller, D.H., In situ aeration of groundwater - a technology overview, in the Proceedings of the Conference on prevention and treatment of soil and groundwater contamination, Montreal, Quebec, 13.0, 1990.

27. Marley, M.C., Walsh, M.T., and Nangeroni, P.E., Case study on the application of air sparging as a complementary technology to vapor extraction at a gasoline spill site in Rhode Island, in Proceedings of HMC Great Lakes 90, Silver Spring, Maryland, 220, 1990.

References

Health Assessment for Kummer Sanitary Landfill, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, June 27, 1989. CERCLIS No. 05MND980904049 (prepared by the Minnesota Department of Health)

Remedial Investigation Final Report, Kummer Sanitary Landfill, Minnesota Pollution Control Agency, January 1990. 0871-03-9

Final Report Feasibility Study for Ground Water Operable Unit, Kummer Sanitary Landfill, Minnesota Pollution Control Agency, July, 1990. (prepared by MP, Inc.)

Unilateral Administrative Order Re: Kummer Sanitary Landfill, Northern Township, Bemidji, Minnesota, U.S. EPA Docket No. V-W-91-C-105, U.S. Environmental Protection Agency, Region V., June 28, 1991.

ROD, Kummer Sanitary Landfill, Operable Unit 3, U.S. EPA, September 1990.

Health Effects Summary Tables (HEAST), Fourth Quarter, 1990, prepared by the Office of Health and Environmental Assessment for the Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency.

Strack, O.D.L., 1989, Groundwater Mechanics, Prentice-Hall, New Jersey.

TABLES

TABLE 1

Comparison of Wastes Generated by Pumping 100 gpm vs 150 gpm
Kummer Landfill
Bemidji, Minnesota
Delta No. 10-91-123

Description	100 gpm	150 gpm
Sludge generated	1 cubic yd/day	1.5 cubic yds/day
Barium generated	0.0887 lb/day	0.11 lb/day
Arsenic generated	0.0151 lb/day	0.302 lb/day
Barium concentration in sludge	98.556 ppm	98.556 ppm
Arsenic concentration in sludge	16.778 ppm	16.778
Transportation costs to RCRA landfill	$56,100.00	$82,500.00*
Transportation costs if hazardous	$44,500.00	$66,750.00
Disposal costs in RCRA landfill	$44,500.00	$66,750.00
GAC use	600 lb/year	900 lb/year

* Cost is not exactly 50 percent greater than 100 gpm cost because transport costs are based on truckloads which must be rounded to nearest whole number.

ppm = parts per million
gpm = gallons per minute

jms.828

TABLE 2

Present Worth of Recommended Alternative 3
Kummers Sanitary Landfill
Bemidji, Minnesota
Delta No. 10-91-123

Scenario	30 year 10% Discount	30 year 4% Discount	4 year 10% Discount	4 year 4% Discount
$1,000,000 capital cost and $240,000 per year O & M (no inorganic treatment)	$ 3,300,000	$ 5,400,000	$ 1,800,000	$ 1,900,000
$1,400,000 capital cost and $510,000 per year O & M (includes inorganic treatment)	$ 6,200,000	$10,800,000	$ 3,000,000	$ 3,300,000

jms.828

TABLE 3

ARARs for Organic Contaminants of Concern
Kummer Sanitary Landfill
Bemidji, Minnesota
Delta No. 10-91-123

Pathway	Contaminant	MN SWQC	Units
Surface Water	Vinyl Chloride	7.6	ug/L
	1,1,2,2-Tetrachloroethylene	8.9	ug/L
	1,1,2-Trichloroethylene	120	ug/L
	Benzene	112	ug/L
	trans-1,2-Dichloroethylene	No criteria	ug/L
		MCLs	**Units**
Ground Water	Vinyl Chloride	2	ug/L
	1,1,2,2-Tetrachloroethylene	5*	ug/L
	1,1,2-Trichloroethylene	5	ug/L
	Benzene	5	ug/L
	trans-1,2-Dichloroethylene	100*	ug/L

SWQC = Surface Water Quality Criteria for Lake Bemidji MN 7050.0220 Class 2B

MCLs = Maximum Contaminant Levels - Safe Drinking Water Act

* = Effective July 1992

jms.830

TABLE 4

Cost Comparison at 10% Discount (Values in $1,000s)

	Alternative 1	Alternative 3	Alternative 4
Capital	73	1,000 - 1,400(1)	403
Annual O & M	24	240 - 510(1)	100
30 Year Present Worth	300	3,300 - 6,200(1)	1,340
4 Year Present Worth	—	1,800 - 3,000(1)	---
10 Year Present Worth	—	—	720

Notes:

(1) First value in range is cost assuming no inorganic treatment; second value assumes inorganic treatment included.

llp.829

TABLE 5

Cost Comparison at 4% Discount (Values in $1,000s)

	Alternative 1	Alternative 3	Alternative 4
Capital	73	1,000 - 1,400(1)	403
Annual O & M	24	240 - 510(1)	100
30 Year Present Worth	516	5,400 - 10,800(1)	2,200
4 Year Present Worth	___	1,900 - 3,300(1)	---
10 Year Present Worth	___	______	770

Notes:

(1) First value in range is cost assuming no inorganic treatment; second value assumes inorganic treatment included.

llp.829

FIGURES

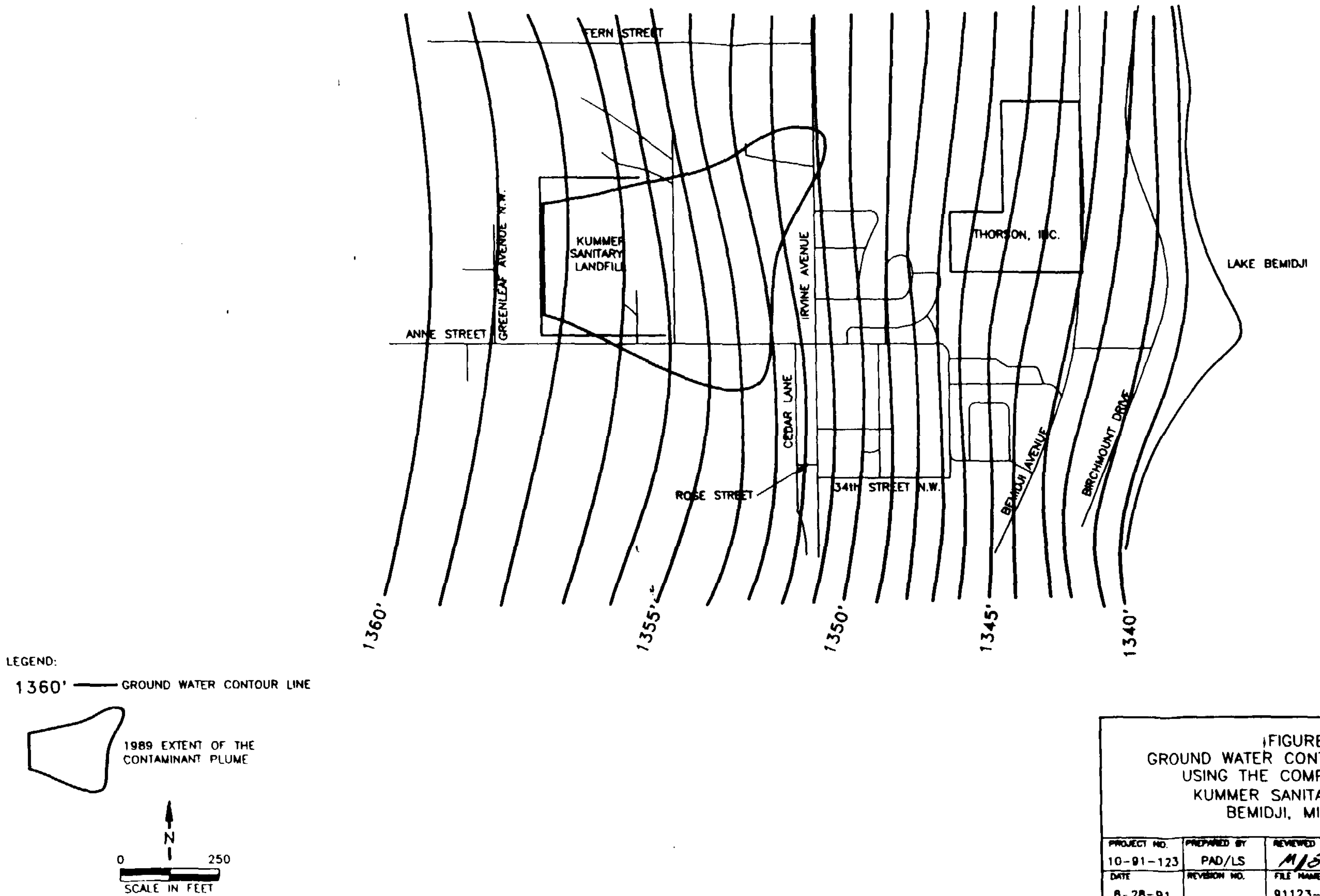


FIGURE 1
GROUND WATER CONTOURS PREDICTED
USING THE COMPUTER MODEL
KUMMER SANITARY LANDFILL
BEMIDJI, MINNESOTA

PROJECT NO.	PREPARED BY	REVIEWED BY	
10-91-123	PAD/LS	MJS	Delta Environmental Consultants, Inc.
DATE	REVISION NO.	FILE NAME	
8-28-91		91123-2	

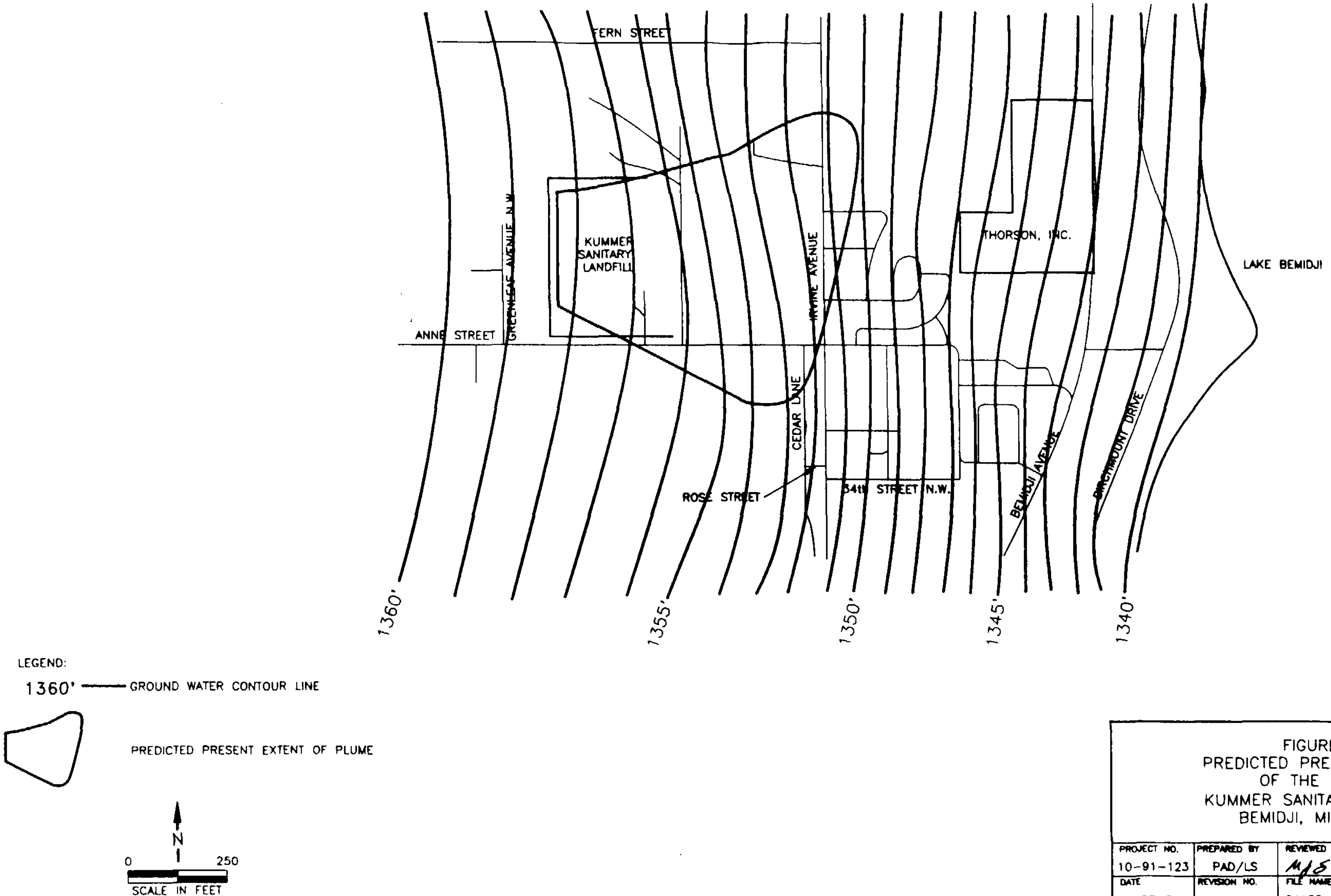


FIGURE 2
PREDICTED PRESENT EXTENT
OF THE PLUME
KUMMER SANITARY LANDFILL
BEMIDJI, MINNESOTA

PROJECT NO.	PREPARED BY	REVIEWED BY
10-91-123	PAD/LS	MJS
DATE	REVISION NO.	FILE NAME
8-28-91		91123-2

Delta Environmental Consultants, Inc.

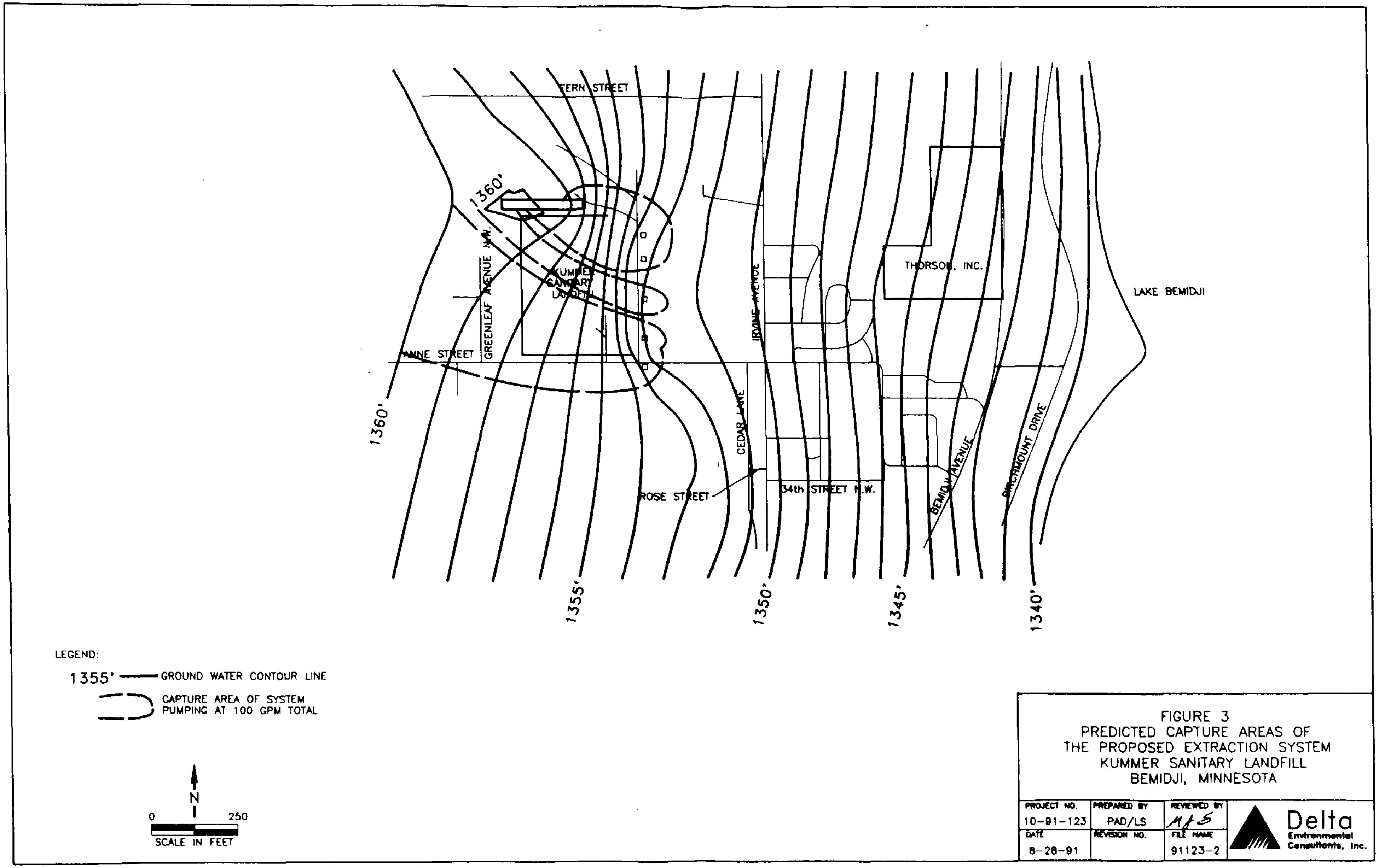


FIGURE 3
PREDICTED CAPTURE AREAS OF
THE PROPOSED EXTRACTION SYSTEM
KUMMER SANITARY LANDFILL
BEMIDJI, MINNESOTA

PROJECT NO.	PREPARED BY	REVIEWED BY	
10-91-123	PAD/LS	MJS	Delta Environmental Consultants, Inc.
DATE	REVISION NO.	FILE NAME	
8-28-91		91123-2	

APPENDIX A

Computer Model Input Files

```
type k.dat
*SLAEM Data Input File
*Kummer Landfill
*Bemidji, Minnesota
*Delta No. 10-91-123

ret
aquifer
  base 280                    *default parameters
  thick 300
  perm 45
  porosity .23
ret
given
  rain .0006852 0 0 1 1 0
  uniflow 6.1 0
ret
window -4050 -2350 4800 3100
well
  given
    -1275 1350 3850   *Proposed pump and treat wells
    -1275 1100 3850
    -1275 650 3850
    -1275 250 3850
    -1275 -75 3850
ret
arel
 given
  -2610 1550 -2610 50 -1350 50 -1350 1550 .00027   *landfill
 given
  -2780 1720 -1930 1720 -1930 1590 -2780 1590 -.1742 *infiltration pond
ret
map
  plot on
  curve
    -3650 0
    1220 0
    1220 -1050   *Tamarack Ave
    2075 -1050
  curve
    -1350 1980
    -1350 0
  curve
    -3600 2750
    0 2750
  curve
    0 3100
    0 -2350
  curve
    -2610 50        *landfill
    -2610 1550
    -1350 1550
    -1350 50
    -2610 50
  curve
    1740 -1880   *Bemidji Ave
    2260 -640
    2460 0
    2560 700
    2630 2300
    2630 3100
  curve
    1840 2300    *Thorson, Inc.
```

```
    2500 700
    1340 700
    1340 1240
    1840 1240
    1840 2300
  curve
    2540 -1650    *Route 17
    3220 0
    3370 360
    3420 540
    3390 740
    3330 1010
    3080 1630
    2970 1900
    2980 2040
    3100 3100
  curve
    2460 0
    3220 0
  curve
    -2550 1340     *plume
    -1900 1460
    -1420 1610
    -850 1700
    -500 1920
    -270 2040
    0 2100
    180 1930
    50 1650
    0 1500
    -170 1180
    -280 860
    -340 460
    -340 -30
    -380 -220
    -520 -380
    -820 -400
    -1050 -340
    -2550 340
    -2550 1340
  point
    -2980 860        *Monitoring Wells
    -2630 180
    -2200 700
    -1870 1720
    -1800 -50
    -1350 -50
    -1280 1000
    -1250 1500
    -675 -50
    50 -50
    630 -950
    1200 -300
    2070 -1550
    2410 -650
    850 1440
    90 560

ret
linesink
  head
        1496   -12848      2464    -8536       339       *Lake Bemidji
        2466    -8536      3696    -6864       339
        3696    -6864      3080    -5808       339
        3080    -5808      3300    -1144       339
```

```
         4150       100      3800      1232      339
         3800      1232      4136      5368      339
         4136      5368      3080     11616      339
         3080     11616      7480     13728      339
         7480     13728     12584     11000      339
        12584     11000     15928      6776      339
        15928      6776     14432         0      339
        14432         0     12320     -3960      339
        12320     -3960     10560    -11440      339
        10560    -11440      6776    -14432      339
         6776    -14432      1496    -13024      339
         1496    -13024      3520    -15928      339
         3520    -15928      2288    -18480      339
         2288    -18480     -2640    -17160      339
        -2640    -17160     -1760    -12936      339
        -1760    -12936     -2816    -12936      339
        -2816    -12936     -1760    -14256      339
        -1760    -14256      1056    -13288      339
         1056    -13288      1496    -12848      339
  com
  head
       -14000     -1852    -12500     -2902      373  *Grass Lake
       -12500     -2902    -14450     -4952      373
       -14450     -4952    -14600     -4052      373
       -14600     -4052    -17600     -2902      373
       -17600     -2902    -19600     -2552      373
       -19600     -2552    -17400     -1230      373
       -17400     -1230    -13000     -1760      373
       -13000     -1760    -14000     -1852      373
ret
doublet
tol 20
inhom 45 300 320 .23   *raised base elevation area
  -2000 1320
  -390 1310
  855 1270
  3040 -2330
  -340 -2350
inhom 25 300 280 .23    *low conductivity area
  -2750 3100
  -1250 3100
  -390 1310
  -2000 1320
com
ret
ref
  -2980 860 359.1                    *MW-5
title
  Kummer Landfill
solve
grid 30
switch
  end
```

The purpose of conducting the computer modeling of the landfill was to:

1) Determine leachate infiltration rates from the landfill into the ground water system during the period when the landfill was closed and uncovered (eight year simulation).

2) Predict the yearly leachate infiltration rate after the landfill is capped (one year simulation).

The model selected for the evaluation is the Hydrologic Evaluation of Landfill Performance (HELP) model which was developed for the U.S Environmental Protection Agency by the Environmental Laboratory of the U.S. Army Engineer Waterways Experminent Station. The model is a quasi-two-dimensional hydrologic model of daily water movement into, through, and out of landfills. This model was originally developed to assist in design evaluations required by the Resource Conservation and Recovery Act (RCRA).
The imput parameters used were obtained from evaluation of the Kummer Landfill Report completed by Malcom Pirnie. Important imput parameters used in the model are:

- Site Location (Influences Precipitation, Temperature, and Solar Radiation);
- Surface Cover;
- Initial Soil Water Content;
- Porosity;
- Field Capacity;
- Wilting Point;
- Saturated Hydraulic Conductivity;
- Number of Soil Layers;
- Soil Layer Type; and
- Soil Layer Thickness.

These parameters are presented on the following pages.

The number of layers and layer thicknesses in the landfill were modified from the uncapped simulation to the capped simulation of the landfill. These changes reflect modifications in the landfill structure implemented during the process of capping the landfill.

****
****

KUMMER LANDFILL
BEMIDJI, MINNESOTA
3/13/91

. UNCOVERED LANDFILL
****
****

FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	216.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000599999970 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.0624 VOL/VOL
WILTING POINT	=	0.0245 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0624 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.005799999926 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	76.25
TOTAL AREA OF COVER	=	2250000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	10.4000 INCHES
INITIAL VEG. STORAGE	=	5.6122 INCHES
INITIAL SNOW WATER CONTENT	=	0.4737 INCHES

SOIL AND WASTE LAYERS = [illegible] INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR DULUTH MINNESOTA

MAXIMUM LEAF AREA INDEX = 2.00
START OF GROWING SEASON (JULIAN DATE) = 152
END OF GROWING SEASON (JULIAN DATE) = 262

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
6.30	12.00	22.90	38.30	50.30	59.40
65.30	63.20	54.00	44.20	28.20	13.30

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 8

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.95	0.89	1.14	2.73	2.94	4.69
	4.03	4.40	3.84	1.73	1.93	1.30
STD. DEVIATIONS	0.64	0.41	0.53	1.31	0.91	1.85
	2.80	1.89	1.72	0.88	1.13	0.52
RUNOFF						
TOTALS	0.000	0.000	0.008	0.000	0.000	0.003
	0.059	0.033	0.007	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.023	0.000	0.000	0.006
	0.147	0.090	0.020	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.226	0.496	1.286	2.948	3.194	4.308
	4.573	4.219	2.726	1.719	0.659	0.289
STD. DEVIATIONS	0.037	0.091	0.415	0.483	1.183	1.308
	1.347	1.128	0.637	0.361	0.169	0.106
PERCOLATION FROM LAYER 2						
TOTALS	0.2762	0.2444	0.2628	0.2740	0.3079	0.3052
	0.3161	0.3212	0.3022	0.3094	0.2933	0.2925
STD. DEVIATIONS	[illegible]	0.1265	0.1548	[illegible]	[illegible]	[illegible]

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 8

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	30.68	(5.647)	5752032.	100.00
RUNOFF	0.111	(0.180)	20727.	0.36
EVAPOTRANSPIRATION	26.643	(3.300)	4995606.	86.85
PERCOLATION FROM LAYER 2	3.5051	(1.3016)	657204.	11.43
CHANGE IN WATER STORAGE	0.419	(3.418)	78493.	1.36

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 8

	(INCHES)	(CU. FT.)
PRECIPITATION	3.13	586875.0
RUNOFF	0.392	73589.3
PERCOLATION FROM LAYER 2	0.0185	3471.7
SNOW WATER	5.35	1002890.8

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3989

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1398

****

****

FINAL WATER STORAGE AT END OF YEAR 8

LAYER	(INCHES)	(VOL/VOL)
1	62.74	0.2905
2	2.50	0.1041
SNOW WATER	3.15	

****

****

```
************************************************************************
************************************************************************

KUMMER LANDFILL
BEMIDJI, MN.
10-91-123

CAPPED LANDFILL
************************************************************************
************************************************************************



                              FAIR GRASS


                              LAYER  1
                              --------

                      VERTICAL PERCOLATION LAYER
THICKNESS                               =     36.00 INCHES
POROSITY                                =      0.4170 VOL/VOL
FIELD CAPACITY                          =      0.0454 VOL/VOL
WILTING POINT                           =      0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT              =      0.0207 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY        =      0.012999999337 CM/SEC


                              LAYER  2
                              --------

                       LATERAL DRAINAGE LAYER
THICKNESS                               =     12.00 INCHES
POROSITY                                =      0.4170 VOL/VOL
FIELD CAPACITY                          =      0.0454 VOL/VOL
WILTING POINT                           =      0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT              =      0.0207 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY        =      0.009999999776 CM/SEC
SLOPE                                   =      3.00 PERCENT
DRAINAGE LENGTH                         =    600.0 FEET


                              LAYER  3
                              --------

                         BARRIER SOIL LINER
THICKNESS                               =     24.00 INCHES
POROSITY                                =      0.4300 VOL/VOL
FIELD CAPACITY                          =      0.3663 VOL/VOL
WILTING POINT                           =      0.2802 VOL/VOL
```

SATURATED HYDRAULIC CONDUCTIVITY = 0.000002000000 CM/SEC

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	60.00 INCHES
POROSITY	=	0.3178 VOL/VOL
FIELD CAPACITY	=	0.0391 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0207 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.009999999776 CM/SEC

LAYER 5

VERTICAL PERCOLATION LAYER

THICKNESS	=	180.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2905 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 6

VERTICAL PERCOLATION LAYER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.0624 VOL/VOL
WILTING POINT	=	0.0245 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1041 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.005799999926 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	38.62
TOTAL AREA OF COVER	=	1219680. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.3400 INCHES
INITIAL VEG. STORAGE	=	0.4140 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	67.3440 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR DULUTH MINNESOTA

MAXIMUM LEAF AREA INDEX = 2.00
START OF GROWING SEASON (JULIAN DATE) = 152
END OF GROWING SEASON (JULIAN DATE) = 262

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
6.30	12.00	22.90	38.30	50.30	59.40
65.30	63.20	54.00	44.20	28.20	13.80

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.47	0.78	1.11	1.17	1.73	3.93
	3.23	3.12	2.93	0.88	3.06	0.89
STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.064	0.036	0.003	0.000	0.037	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.166	0.814	1.130	1.154	1.425	4.292
	2.391	4.060	2.255	0.548	0.442	0.460
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
LATERAL DRAINAGE FROM LAYER 2						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0182
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	1.2741
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION FROM LAYER 6

TOTALS	0.2183	0.1734	0.1764	0.1601	0.1571	0.1455
	0.1447	0.1395	0.1305	0.1306	0.1226	0.1230
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 1

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	23.30	(0.000)	2368212.	100.00
RUNOFF	0.140	(0.000)	14257.	0.60
EVAPOTRANSPIRATION	19.136	(0.000)	1944995.	82.13
LATERAL DRAINAGE FROM LAYER 2	0.0182	(0.0000)	1852.	0.08
PERCOLATION FROM LAYER 3	1.2741	(0.0000)	129504.	5.47
PERCOLATION FROM LAYER 6	1.8217	(0.0000)	185156.	7.82
CHANGE IN WATER STORAGE	2.184	(0.000)	221952.	9.37

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 1

	(INCHES)	(CU. FT.)
PRECIPITATION	1.07	108754.8
RUNOFF	0.064	6467.8
LATERAL DRAINAGE FROM LAYER 2	0.0018	185.3
PERCOLATION FROM LAYER 3	0.0699	7100.1
HEAD ON LAYER 3	0.7	
PERCOLATION FROM LAYER 6	0.0076	775.2
SNOW WATER	0.57	57546.5

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1264

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0173

****

****

FINAL WATER STORAGE AT END OF YEAR 1

LAYER	(INCHES)	(VOL/VOL)
1	2.68	0.0746
2	0.55	0.0455
3	10.32	0.4300
4	2.51	0.0419
5	50.68	0.2815
6	2.29	0.0956
SNOW WATER	0.49	

****
****

APPENDIX B

Costs Comparisons

KUMMER'S LANDFILL PRESENT WORTH ANALYSIS
DELTA NO:10-91-123

ALTERNATIVE I - NO FURTHER ACTION
$73,000 CAPITAL COST AND $24,000 ANNUAL O&M

30-YEAR PRESENT WORTH

YEAR	CAPITAL COSTS	FUTURE VALUE O&M COSTS (6% INFLATION)	FUTURE VALUE TOTAL COST PER YEAR	PRESENT VALUE (10% RETURN)
1	$73,000.00	$24,000.00	$97,000.00	$97,000.00
2		$25,440.00	$25,440.00	$23,127.27
3		$26,966.40	$26,966.40	$22,286.28
4		$28,584.38	$28,584.38	$21,475.87
5		$30,299.45	$30,299.45	$20,694.93
6		$32,117.41	$32,117.41	$19,942.39
7		$34,044.46	$34,044.46	$19,217.21
8		$36,087.13	$36,087.13	$18,518.40
9		$38,252.35	$38,252.35	$17,845.01
10		$40,547.50	$40,547.50	$17,196.10
11		$42,980.34	$42,980.34	$16,570.78
12		$45,559.17	$45,559.17	$15,968.21
13		$48,292.72	$48,292.72	$15,387.55
14		$51,190.28	$51,190.28	$14,828.00
15		$54,261.69	$54,261.69	$14,288.80
16		$57,517.40	$57,517.40	$13,769.21
17		$60,968.44	$60,968.44	$13,268.51
18		$64,626.55	$64,626.55	$12,786.02
19		$68,504.14	$68,504.14	$12,321.07
20		$72,614.39	$72,614.39	$11,873.03
21		$76,971.25	$76,971.25	$11,441.29
22		$81,589.53	$81,589.53	$11,025.24
23		$86,484.90	$86,484.90	$10,624.32
24		$91,673.99	$91,673.99	$10,237.98
25		$97,174.43	$97,174.43	$9,865.69
26		$103,004.90	$103,004.90	$9,506.94
27		$109,185.19	$109,185.19	$9,161.23
28		$115,736.30	$115,736.30	$8,828.10
29		$122,680.48	$122,680.48	$8,507.08
30		$130,041.31	$130,041.31	$8,197.73
				$515,760.23

4-YEAR PRESENT WORTH

YEAR	CAPITAL COSTS	FUTURE VALUE O&M COSTS (6% INFLATION)	FUTURE VALUE TOTAL COST PER YEAR	PRESENT VALUE (10% RETURN)
1	$73,000.00	$24,000.00	$97,000.00	$97,000.00
2		$25,440.00	$25,440.00	$23,127.27
3		$26,966.40	$26,966.40	$22,286.28
4		$28,584.38	$28,584.38	$21,475.87
				$163,889.42

KUMMER'S LANDFILL PRESENT WORTH ANALYSIS
DELTA NO:10-91-123

ALTERNATIVE III - ADVANCED OXIDATION PROCESS W/O INORGANIC TREATMENT
$1,000,000 CAPITAL COST AND $240,000 ANNUAL O&M

30-YEAR PRESENT WORTH

YEAR	CAPITAL COSTS	FUTURE VALUE O&M COSTS (6% INFLATION)	FUTURE VALUE TOTAL COST PER YEAR	PRESENT VALUE (10% RETURN)
1	$1,000,000.00	$240,000.00	$1,240,000.00	$1,240,000.00
2		$254,400.00	$254,400.00	$231,272.73
3		$269,664.00	$269,664.00	$222,862.81
4		$285,843.84	$285,843.84	$214,758.71
5		$302,994.47	$302,994.47	$206,949.30
6		$321,174.14	$321,174.14	$199,423.87
7		$340,444.59	$340,444.59	$192,172.09
8		$360,871.26	$360,871.26	$185,184.02
9		$382,523.54	$382,523.54	$178,450.05
10		$405,474.95	$405,474.95	$171,960.96
11		$429,803.45	$429,803.45	$165,707.83
12		$455,591.65	$455,591.65	$159,682.10
13		$482,927.15	$482,927.15	$153,875.47
14		$511,902.78	$511,902.78	$148,280.00
15		$542,616.95	$542,616.95	$142,888.00
16		$575,173.97	$575,173.97	$137,692.07
17		$609,684.40	$609,684.40	$132,685.09
18		$646,265.47	$646,265.47	$127,860.18
19		$685,041.40	$685,041.40	$123,210.72
20		$726,143.88	$726,143.88	$118,730.33
21		$769,712.51	$769,712.51	$114,412.86
22		$815,895.26	$815,895.26	$110,252.39
23		$864,848.98	$864,848.98	$106,243.21
24		$916,739.92	$916,739.92	$102,379.83
25		$971,744.31	$971,744.31	$98,656.92
26		$1,030,048.97	$1,030,048.97	$95,069.40
27		$1,091,851.91	$1,091,851.91	$91,612.33
28		$1,157,363.03	$1,157,363.03	$88,280.97
29		$1,226,804.81	$1,226,804.81	$85,070.75
30		$1,300,413.10	$1,300,413.10	$81,977.27
		NET PRESENT VALUE TOTAL-		$5,427,602.28

4-YEAR PRESENT WORTH

YEAR	CAPITAL COSTS	FUTURE VALUE O&M COSTS (6% INFLATION)	FUTURE VALUE TOTAL COST PER YEAR	PRESENT VALUE (10% RETURN)
1	$1,000,000.00	$240,000.00	$1,240,000.00	$1,240,000.00
2		$254,400.00	$254,400.00	$231,272.73
3		$269,664.00	$269,664.00	$222,862.81
4		$285,843.84	$285,843.84	$214,758.71
		NET PRESENT VALUE TOTAL-		$1,908,894.24

KUMMER'S LANDFILL PRESENT WORTH ANALYSIS
DELTA NO:10-91-123

ALTERNATIVE III - ADVANCED OXIDATION PROCESS WITH INORGANIC TREATMENT
$1,400,000 CAPITAL COST AND $510,000 ANNUAL O&M

30-YEAR PRESENT WORTH

YEAR	CAPITAL COSTS	FUTURE VALUE O&M COSTS (6% INFLATION)	FUTURE VALUE TOTAL COST PER YEAR	PRESENT VALUE (10% RETURN)
1	$1,400,000.00	$510,000.00	$1,910,000.00	$1,910,000.00
2		$540,600.00	$540,600.00	$491,454.55
3		$573,036.00	$573,036.00	$473,583.47
4		$607,418.16	$607,418.16	$456,362.25
5		$643,863.25	$643,863.25	$439,767.26
6		$682,495.04	$682,495.04	$423,775.73
7		$723,444.75	$723,444.75	$408,365.70
8		$766,851.43	$766,851.43	$393,516.04
9		$812,862.52	$812,862.52	$379,206.36
10		$861,634.27	$861,634.27	$365,417.04
11		$913,332.33	$913,332.33	$352,129.15
12		$968,132.26	$968,132.26	$339,324.45
13		$1,026,220.20	$1,026,220.20	$326,985.38
14		$1,087,793.41	$1,087,793.41	$315,095.00
15		$1,153,061.02	$1,153,061.02	$303,637.00
16		$1,222,244.68	$1,222,244.68	$292,595.66
17		$1,295,579.36	$1,295,579.36	$281,955.82
18		$1,373,314.12	$1,373,314.12	$271,702.88
19		$1,455,712.97	$1,455,712.97	$261,822.77
20		$1,543,055.75	$1,543,055.75	$252,301.94
21		$1,635,639.09	$1,635,639.09	$243,127.33
22		$1,733,777.44	$1,733,777.44	$234,286.33
23		$1,837,804.08	$1,837,804.08	$225,766.83
24		$1,948,072.33	$1,948,072.33	$217,557.13
25		$2,064,956.67	$2,064,956.67	$209,645.96
26		$2,188,854.07	$2,188,854.07	$202,022.47
27		$2,320,185.31	$2,320,185.31	$194,676.20
28		$2,459,396.43	$2,459,396.43	$187,597.06
29		$2,606,960.22	$2,606,960.22	$180,775.35
30		$2,763,377.83	$2,763,377.83	$174,201.70
		NET PRESENT VALUE TOTAL -		$10,808,654.84

4-YEAR PRESENT WORTH

YEAR	CAPITAL COSTS	FUTURE VALUE O&M COSTS (6% INFLATION)	FUTURE VALUE TOTAL COST PER YEAR	PRESENT VALUE (10% RETURN)
1	$1,400,000.00	$510,000.00	$1,910,000.00	$1,910,000.00
2		$540,600.00	$540,600.00	$491,454.55
3		$573,036.00	$573,036.00	$473,583.47
4		$607,418.16	$607,418.16	$456,362.25
		NET PRESENT VALUE TOTAL -		$3,331,400.27

APPENDIX C

Minnesota Department of Health Well Advisory

Minnesota Department of Health
Division of Environmental Health
925 Delaware Street Southeast
P.O. Box 59040
Minneapolis, MN 55459-0040

MEMORANDUM

DATE: August 12, 1991

TO: Northern Township Board

FROM: Raymond W. Thron, Ph.D., P.E., Director
Division of Environmental Health
Raymond W. Thron

SUBJECT: Groundwater Contamination and Water Well Advisory--Northern Township, Beltrami County, Minnesota

NOTIFICATION OF WELL ADVISORY

The Minnesota Department of Health (MDH) is issuing a WELL ADVISORY for the portions of Northern Township, Beltrami County, as shown and described on the attached map.

The surficial aquifer within much of the described advisory area has been contaminated with leachate from Kummer Sanitary Landfill. The WELL ADVISORY reflects our concern that the drilling of new wells, or the deepening of existing wells within the advisory area, may result in contamination of deeper, normally protected aquifers. The MDH is also concerned about the public health effects that could result from further development of water wells in contaminated aquifers.

BOUNDARIES OF THE ADVISORY AREA

The advisory area is bounded on the north by Fern Street and the section line between Sections 28 and 33. The southern boundary is defined by Rose Street and a line running due west from Rose Street to the North Country Hospital, 34th Street Northwest, and a line extending due east from 34th Street Northwest to Lake Bemidji. The eastern boundary is defined by Lake Bemidji. The western boundary is defined by a north-south line set 500 feet to the west of Greenleaf Avenue Northwest.

REQUIREMENTS OF THE WELL ADVISORY

1. Within the advisory area, the deepening of existing wells or the construction of any new types of wells, is prohibited until further notice. This ban includes the installation of shallow sand point wells. The shallow wells are of particular concern because the majority of the known contamination exists within the shallow aquifers (less than 40 feet in depth).

2. Wells other than domestic water wells, i.e., dewatering wells for construction purposes, will be considered on an individual basis and, if allowed, would require a variance from the MDH.

3. It is recommended that the MDH be contacted before the construction of any large capacity wells within one mile of the advisory area boundaries. These are wells with a drawdown capacity that could significantly alter the existing groundwater flow patterns. Examples of such wells are municipal, industrial, or dewatering wells. These wells usually require a groundwater appropriations permit from the Minnesota Department of Natural Resources (DNR).

4. Within the advisory area any wells other than monitoring wells, with water found to currently contain, or have in the past, contained contamination levels exceeding the MDH Recommended Allowable Limits (RALs) shall be permanently sealed and abandoned by a licensed water well contractor.

5. Within the advisory area, <u>all</u> wells located west of Tamarack Avenue Northwest and west of the line running due north of Tamarack Avenue Northwest shall be sealed unless it can be shown in each individual well that the levels of contamination do not exceed MDH RALs. To have a well tested for contamination, the water must be analyzed for the contaminants of concern using MDH Method 465D or an equivalent method. An MDH inspector must be present at the time each well

is sampled or the well owner must contract with a certified lab to collect and analyze their water sample. All water samples must be submitted to the laboratory by October 15, 1991.

6. In the event of the sale of any property, or any other type of property title transfer within the entire advisory area, if there is an existing well on the property, the well water shall be tested for contamination. If levels of contamination are found that exceed MDH RALs, the well shall be permanently sealed and abandoned by a licensed water well contractor.

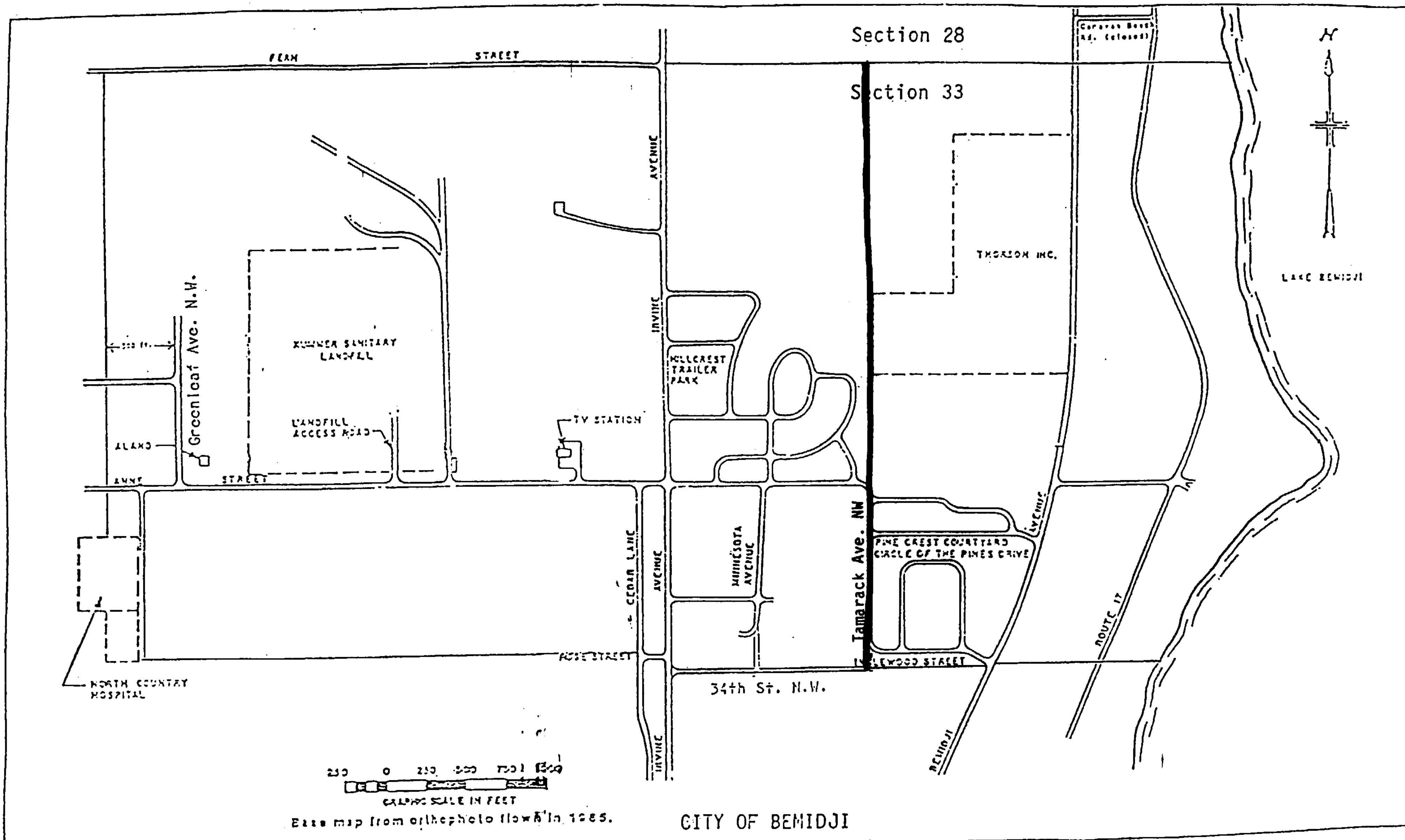
7. Total compliance must be met by December 1, 1991.

In the future, the restrictions and boundaries of this advisory area may change. This would be based on the extent of changes in contamination levels and flow directions of the contaminant plume. The indicator chemicals chosen for study in this area include tetrachloroethene, trichloroethene, trans-1,2-dichloroethene, vinyl chloride, and benzene. Tetrachloroethene and vinyl chloride have already been found at levels exceeding the MDH RALs in several wells, and are the most commonly found contaminants.

Payment assistance for well sealing may be requested through Minnesota's Harmful Substance Compensation Board. Please contact Jean Small-Johnson at 612/642-0455.

If you have any questions regarding this advisory, contact Steve Gruber of the MDH in Bemidji at 218/755-3820 or Ed Schneider of the MDH in Duluth at 218/723-4642.

RWT:SG:fal
Attachment
cc: David Gray, MDH
Steve Gruber, MDH
Miriam Horneff, MPCA
Bill Patnaude, Beltrami County Planning and Zoning
Ann Allen, Beltrami County Recorder



KUMMER'S LANDFILL WELL ADVISORY AREA
Northern Township, Beltrami County, Minnesota

MINNESOTA DEPARTMENT OF HEALTH

July 1991.

The advisory area is bounded on the north by Fern Street and the section line between Sections 28 and 33. The southern boundary is defined by a line running straight west from Rose Street to the North Country Hospital, 34th Street. N.W., and a line extending straight east from 34th Street N.W. to Lake Bemidji. The eastern boundary is defined by Lake Bemidji. The western boundary is defined by a north/south line set 500 feet to the west of Greenleaf Avenue, N.W.

APPENDIX D

USEPA Memorandum on the Use of Innovative Treatment Technologies

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN 10 1991

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

OSWER Directive
9380.0-17

MEMORANDUM

SUBJECT: Furthering the Use of Innovative Treatment Technologies in OSWER Programs

FROM: Don R. Clay
Assistant Administrator

TO: Director, Waste Management Division,
Regions I, IV, V, VII, and VIII
Director, Environmental Services Division,
Regions I, VI, and VII
Director, Emergency and Remedial Response Division,
Region II
Director, Hazardous Waste Management Division,
Regions III, VI and IX
Director, Hazardous Waste Division, Region X
Director, Water Management Division, Regions IV and X

I want to exercise further leadership in the use of innovative technologies--by creating additional incentives for affected groups such as potentially responsible parties, facility owners/operators, consulting engineers, technology vendors and the public and by using tools currently at our disposal. EPA and responsible parties or facility owners/operators, should be exploring and promoting more effective and less costly technologies to solve the considerable problems we face. Consulting engineers and new technology vendors are essential partners in this process as well.

While I believe our clean-up partners can and will promote the implementation of innovative technology, we need to inject a sense of responsible urgency to prevent the expenditure of dollars in pursuing less effective or more costly remedies. We have made some important progress to date, and now is the time to broaden our efforts and expand into additional program areas. Furthermore, we have a responsibility to provide technological leadership to the other major environmental clean-up programs society will be pursuing beyond those administered by OSWER. This leadership will not only improve the quality and efficiency of cleanups, but will also help make U.S. firms leaders in the international marketplace for waste treatment and site remediation.

Each of the affected groups sees some risk tied to an effort to "push on the envelope" of technology application. However, these risks are directly related to potential benefits -- both short-term at a particular site and long-term benefits which will accrue from knowledge gained by our experiences. Only if some of us are willing to work constructively with our uncertainty is there reason to expect significant progress toward more applications of technologies that are truly innovative.

I understand innovation requires a sense of creativity and may be accompanied by false starts, second attempts, intensively re-engineered solutions, and (despite best efforts) some equipment failures. I recognize that while most will agree with the need for new and better approaches, the inherent risks associated with early technology use serve as very serious impediments. The extensive review and criticism of our programs from both outside and inside the Agency may have tended to make us averse to unnecessary risks. It should be recognized that however well-designed and carefully planned our efforts may be, they may not meet contract specifications on many first attempts and may need refinement before routine application can be expected. Indeed, information gained from a first-time application that fails to perform as designed may be viewed as a form of success.

In addition, this definition of innovation needs to be recognized by EPA regional and headquarters managers. Remedial Project Managers (RPMs) and On-Scene Coordinators (OSCs) must have support from their managers if an innovative technology does not work as expected. The program should recognize and assume the risks inherent in using new technologies. The challenges these projects present will usually require great efforts from our most competent and experienced RPMs and OSCs. They should view these challenges as career opportunities rather than as career risks.

Innovative treatment technologies should be routinely considered as an option in engineering studies where treatment is appropriate. They should not be eliminated from consideration solely because of uncertainties in their performance and cost. These technologies may be found to be cost-effective, despite the fact the their costs are greater than conventional options, after consideration of potential benefits which could include increased protection, superior performance, and greater community acceptance. In addition, future sites will benefit by information gained from the field experience.

The attached directive is designed to increase field applications of innovative technologies for cleaning up contaminated sites. It also encourages expanded application of existing OSWER policies and emphasizes the value of existing support activities in this area. It is intended to sharpen the focus and level of attention by EPA staff and managers on their mission to provide technological leadership by implementing existing authorities under the Superfund, Resource Conservation and Recovery Act (RCRA), Underground Storage Tank (UST), and Oil

Pollution Act programs. Furthermore, this guidance is intended to integrate the continual search for improved remedies with the use of new technologies and to make this objective a permanent feature of EPA's clean-up programs. It is intended to create an atmosphere which recognizes that reasonable risk-taking, which is protective of human health and the environment, is necessary to achieve this end.

The statement consists of seven major initiatives. The first four initiatives concern the Superfund program. The first one addresses some impediments to the full-scale use of new equipment and encourages expedited funding of remedial design and construction projects. This initiative also provides contract flexibility in the start-up phase of selected remedial and removal actions to assist vendors in establishing a pattern of reliable operation in order to satisfy contract performance standards. The second initiative is intended to ensure that innovative alternatives are thoroughly evaluated for PRP-lead sites that are early in the planning process. This provision encourages EPA regions to fund treatability studies and engineering analyses for promising treatment technologies that might otherwise be considered unproven by the PRPs and too early in the development process. The third initiative provides a capability to rapidly evaluate the efficacy of a PRP-proposed innovative remedy that is offered in addition to the primary one approved in the Record of Decision (ROD). This provision entails direct technical support to evaluate innovative remedies, while moving the remediation process forward. The fourth initiative seeks to utilize the potential of the removal program for expanding our experience with the field application of new technologies. The directive clarifies OSWER's position that the removal program is an important and viable means for furthering the use of these treatment alternatives.

Another provision in the guidance is designed to encourage studies on the potential use of new technologies for RCRA corrective action. Regions should consider promoting the pilot testing of promising innovative technologies at a limited number of sites. In the past, land ban considerations have sometimes discouraged owners/operators or regions from pursuing such approaches. This guidance encourages the use of soil and debris treatability variances, where necessary, to allow innovative technology studies to proceed. This authority was recently delegated to the regions.

The sixth initiative recognizes unique opportunities presented by Federal facilities. We are exploring the potential use of these facilities for developing and applying new technologies, and regional offices are encouraged to work with Federal facility managers to further this objective.

The final provision encourages expanded use of the Federal Technology Transfer Act as an opportunity for joint technology assessments with industry. PRPs and owners/operators may sign cooperative agreements with EPA for services to support innovative technology treatability or pilot studies. This procedure offers the prospect of non-adversarial engagement, outside the regulatory context, to allow the development of third-party data on remediation technologies.

I know there is a tension created by the desire to promote new technology developments within existing management tracking systems and program commitments and goals. I recognize that these goals may also be statutory in origin. Issues are certain to arise concerning the selection and use of new treatment technologies because of the rapid pace of development in this area. These issues cannot be resolved by this guidance and must be addressed through common sense and judgement on a case-by-case basis. There may be circumstances where program goals and commitments must be adjusted in order to achieve better clean-up solutions.

Although not specifically discussed in the attached guidance, EPA is also strongly committed to using innovative technologies in cleaning up oil spills under the Oil Pollution Act. We have embarked on an aggressive research program with other Federal agencies and the private sector to examine clean-up technologies and remediation techniques. We anticipate this work will lead to new and improved technologies in this area as well.

This directive is a call for your attention to exploring and exploiting opportunities for using innovative remediation technologies. It reflects my personal commitment and belief that we must invest the necessary resources and take the risks now to develop the technologies necessary to fulfill the long-term needs of our hazardous waste clean-up programs.

GUIDANCE FOR INCREASING THE APPLICATION OF INNOVATIVE TREATMENT TECHNOLOGIES FOR CONTAMINATED SOIL AND GROUND WATER

INTRODUCTION

The Office of Solid Waste and Emergency Response (OSWER) is seeking to further the use of innovative treatment technologies in order to (1) better pursue its statutory and regulatory mandates to promote treatment to the maximum extent practicable, (2) speed the availability of performance data regarding newly developed treatment technologies to many constituencies facing mandates to clean contaminated sites, (3) broaden the inventory of accepted treatment-based solutions, and (4) increase the likelihood that remediation costs can be lowered in the near term through the demonstration of a larger number of engineering options to solve site remediation problems.

Both SARA and HSWA give us the framework to consider treatment as an essential element in our clean-up decisionmaking. Our record of accomplishment since SARA in selecting treatment technologies for Superfund remedial and removal projects is very good. However, our experience in implementing remedies is limited, and we face a large future obligation to cleanup sites in the RCRA and UST programs. For example, the large number of cleanups expected under the RCRA corrective action program may encompass up to 4,000 facilities and 64,000 waste management units.

Section 121(b) of CERCLA requires EPA to select remedies that "utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable" and to prefer remedial actions in which treatment "permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants as a principal element." This objective of permanent treatment-based remedies should be applied to RCRA and UST cleanups, within their respective legislative contexts. To achieve this goal, EPA must encourage new or innovative treatment technologies that are capable of treating contaminated soils/sludges and ground water more effectively, less expensively, and in a manner more acceptable to the public than existing conventional methods.

Innovative treatment technologies are newly developed technologies whose lack of sufficient full-scale application blocks routine consideration for site remediation. They may be new technologies, or may be available and in use for various industrial applications other than hazardous waste remediation. As such, innovative technologies are not part of standard engineering practice or the competitive market process where available alternatives are routinely presented to the government and private sector. In functional terms, we define as "innovative" those treatment technologies for source control <u>other than</u> incineration and solidification/stabilization and pumping with conventional treatment for ground water. Innovative technologies inherently require extra effort to gather information and analyze options and extra engineering and financial risk in adapting them for specific site applications. In addition, there is extra uncertainty for people developing such solutions who work in organizations focused on performance outcomes with high levels of certainty and known costs.

Existing directives and guidance contain a number of references that encourage the consideration of innovative technologies. Policy for the Superfund program was originally outlined in a February 21, 1989 memorandum on "Advancing the Use of Treatment Technologies for Superfund Remedies." This memorandum reaffirmed the use of treatment technologies and summarized guidance documents and activities that supported the use of innovative technologies. It cited the need to search for new technologies that can improve performance and reduce cost. The importance of innovative technologies was further emphasized in the <u>Superfund Management Review</u> (90-Day Study) which primarily contained recommendations concerning technical support and research. More recently, the National Contingency Plan expects that treatment will be used for highly toxic and highly mobile waste and encourages the consideration of innovative methods.

As a result of SARA and this guidance, the selection of innovative technologies in the remedial program has increased dramatically. For the last three fiscal years, almost half of the selected treatment technologies for source control have been innovative. However, few full-scale innovative remedies have actually been implemented. As a result, we are not benefiting from actual clean-up experience or developing the equipment necessary to fulfill long-term program needs. This directive seeks to preserve our momentum with the selection of these technologies, to expedite their use in remedial actions,to expand the application of new technologies to other OSWER programs, and to realize the potential for development and technology application at Federal facilities.

This directive sets forth several initiatives and new procedures that will help provide incentives for broader use of innovative technology. Some of these initiatives are directed toward potential responsible parties and owners/operators, since they will be assuming a larger share of the remedial projects in the future. Other new initiatives are intended to remove impediments to the first-time use of new equipment. The directive also encourages wider application of available resources and tools. In addition, Attachment A highlights some important ongoing program efforts that deserve mentioning.

STATEMENT OF INTENT

Innovative treatment technologies are to be routinely considered as an option in feasibility studies for remedial sites and engineering evaluations for removals in the Superfund program, where treatment is appropriate commensurate with the National Contingency Plan (NCP) expectations. In addition, innovative treatment-based remedies should be pursued to the extent practicable for cleanup of RCRA and UST units that pose significant health and environmental threats similar to those at Superfund sites. EPA should exercise leadership with state UST programs to encourage similar approaches for underground tanks. Innovative technologies considered in the remedy selection process for Superfund, RCRA, and UST should not be eliminated solely on the grounds that an absence of full-scale experience or treatability study data makes their operational performance and cost less certain than other forms of remediation.

When assessing innovative technologies, it is important to fully account for their benefits. Despite the fact that their costs may be greater than conventional options, innovative technologies may be found to be cost-effective, after accounting for such factors as increased protection, superior performance, and greater community acceptance. In addition, experience gained from the application of these solutions will help realize their potential benefits at other sites with similar contaminants.

NEW INITIATIVES

This directive prescribes six new initiatives affecting Superfund and RCRA programs to encourage and further enable the field application of innovative technologies and their evaluation for potential further use. It also affirms the use of a relatively little-used opportunity for joint EPA work with PRPs and owners/operators to evaluate new technologies.

1. Superfund Innovative Technology Start-Up Initiative.

   Designed for Fund-lead projects, this initiative consists of two efforts to assist the early application of new technology. First, we need to encourage the expedited funding of remedial design and construction projects that involve innovative treatment technologies. *OERR will be revising its Remedial Action funding priority-setting procedures to give more consideration to innovative technologies.* Earlier funding of these projects will help achieve the technology development goals of the Superfund program and will provide EPA with significant data to support future Records of Decisions (RODs).

Second, *this initiative provides contract flexibility in the start-up phase of selected remedial and removal actions to assist vendors in establishing a pattern of reliable operation that satisfies performance standards.* This is intended to address some of the impediments to the use of new full-scale equipment; it will support initial start-up and shake-down costs and modifications necessary to effectively evaluate whether the selected technology can perform to specifications prior to beginning actual remediation. In the remedial program, the Corps of Engineers (COE) will provide separate contract provisions that will aid in the commencement of operations of a unit process or integrated set of processes and will be available only for some proportion of the whole site remedy (e.g., processing the first 1,000 cu. yds. of a 30,000 cu. yd. site). Funds are <u>not</u> targeted at making the technology work at any cost, but to aid in clearly establishing the likely performance adequacy of the technology prior to the onset of the contracted clean-up effort. Contracting strategies are being considered to compensate vendors, regardless of whether they successfully achieve performance limits. Further implementation guidance for the remedial and removal programs will be issued later this year.

2. Dual Track RI/FS Initiative (Superfund)

This initiative is designed for PRP-lead sites that are early in the planning process where there is an opportunity to conduct engineering evaluations of remedies through the RI/FS process. This initiative is intended to ensure that innovative technologies are thoroughly evaluated and that needed treatability studies are conducted for potential remedies. This provision should help encourage EPA to take risks (when faced with reluctant PRPs) that it would not otherwise take by encouraging a comprehensive evaluation of technologies. *EPA regions may fund additional treatability studies and engineering analyses for promising treatment technologies that would otherwise be considered unproven and too early in the development process.* The purpose of this initiative is to encourage treatability studies to ensure that alternative remedies that the government believes may have merit are thoroughly evaluated and considered in the ROD. Data from EPA treatability studies and the evaluation of additional innovative technologies have intrinsic value to the Agency. Therefore, even if, in a particular case, there may be some doubt as to EPA's ability to cost recover for these additional studies (although, in general, the Agency would expect such costs to be subject to cost recovery), these studies should be pursued based on their value to the overall program.

3. Tandem ROD Evaluation Initiative (Superfund)

As in the previous initiative, this provision is primarily designed for PRP-lead sites, although it may also be applicable for some Fund-financed situations. *This program will provide a capability to rapidly evaluate the efficacy of a PRP-proposed innovative remedy that is offered in tandem with the primary one approved in the ROD.* Both of the remedies would be part of the proposed plan. Typically, such an alternate solution would be approved on a contingent basis in the ROD based on acceptable treatability studies, but it would need further development and pilot testing during the design period for the primary technology. Tandem RODs (or contingent RODS based on formal evaluation) are a decision vehicle designed to move the process of cleanup toward expeditious closure, while leaving room for PRPs with a decided interest in innovative technologies to pursue additional pilot tests to demonstrate an alternate approach that is both innovative and potentially cost-effective. This program is based on direct technical support for regional project management teams to help resolve technical issues posed by alternate approaches; it is designed to lift the burden from the regional project manager of bearing the risks of evaluating and trying something "new."

Technical support will be provided for focused evaluation of the PRP work so as to support expedient regional decisions about the acceptability of the alternate technology. The work will be carried out with and through the appropriate OSWER/ORD Technical Support Centers or the SITE demonstration program and will be conducted as a mini-evaluation of the proposed alternative so that the data will be available for future applications. When considering whether to proceed with a tandem ROD, regions should first consult with ORD concerning the scope of effort required for the evaluation.

In the case in which the secondary innovative technology is chosen for implementation (after the completion of pilot testing) but significant delays to the original schedule have occurred, the region may consider the engineering problems of making the full-scale unit operational in assessing stipulated penalties. That is, in limited cases, stipulated penalties should not be imposed if the delays are the unavoidable result of being innovative.

4. Removal Program Initiative (Superfund)

The removal program represents an important and viable means for expediting the field application of innovative technologies. The relatively small volumes frequently requiring response and streamlined contracting procedures provide an opportunity to complete clean-up projects and provide documentation on lessons learned relatively quickly. Smaller waste volumes at some sites may also allow the use of pilot-scale technologies under some circumstances.

Although there have been more innovative projects actually constructed through the removal program than the remedial program, its potential has not been fully realized. This is because time constraints often favor excavation and off-site disposal or treatment and also because of the absence of clear legislated goals regarding the use of new technology. This subject was one of the issues addressed in a 1988 audit report by the Inspector General of Region IV removal sites. The report has had the undesirable effect of discouraging OSCs from using these technologies.

This directive is meant to clarify EPA's position on this issue. *It is OSWER policy to further the use of innovative technologies through the removal program.* This includes all actions, including time-critical actions, where feasible. These projects are expected to fulfill an important role in adding to our knowledge base on promising new technologies. Further guidance will be included in an upcoming document, "Administrative Guidance for Removal Program Use of Alternatives to Land Disposal" (OSWER Directive 9380.2-1), which provides guidelines promoting the use of alternatives to land disposal.

5. RCRA Corrective Action and Closure Innovative Technology Initiative

We are currently engaged in efforts to develop best demonstrated available technology (BDAT) treatment standards for contaminated soil and debris at CERCLA and RCRA corrective action and closure sites. These sites present unique treatment problems that were not generally considered in developing the current BDAT standards, which were based on data from the treatment of industrial process wastes. There is general agreement that wide scale use of incineration is not appropriate for soil and debris, and there is a need to explore alternative approaches. The current schedule is to promulgate a rule for debris in May 1992 and soil in April 1993. Prior to publication of these final rules, <u>a site-specific treatability variance process (40 CFR 268.44 (h)) is available for contaminated soil and debris</u> to establish an alternative standard for specified waste at individual sites. The variance process, along with applicable guidance treatment levels, is described in Superfund LDR Guide #6A (OSWER Directive: 9347.3-06FS, July 1989), and is intended to be used as an interim approach until final standards are established.

This initiative encourages the regions to use treatability variances at corrective action and closure sites *to conduct treatability or technology demonstration studies to gain additional information on the use of innovative treatment for contaminated soil and debris.* The regions should select appropriate pilot-scale projects with cooperative owners/operators that can provide data on the capability of technologies and the treatability of different wastes. The information from this work should help to expedite corrective action and closures after the final BDAT rule is published for soils. It is also possible that early data from this effort could be available for consideration in the final rule.

Projects should be carefully selected to maximize the utility of data and likelihood of success. Regional corrective action staff and regional Superfund staff should communicate regarding the history of use of treatability variances in the Superfund program to identify site factors that require consideration when selecting an appropriate site.

Authority for issuing site-specific variances for contaminated soil and debris has recently been delegated to the regions (Decision Memorandum: "Delegation of Authority to Grant Treatability Variances," from Charles L. Grizzle to the Administrator, April 12, 1991). The facility and EPA, in collaboration with the state, can implement variances for on-site demonstrations through two mechanisms: temporary authorization under the Permit Modification Rule, or 3008(h) orders for interim-status facilities.

6. Demonstration Projects at Federal Facilities (Superfund, RCRA, and UST)

Federal facilities offer unique opportunities for both developing and applying innovative approaches to hazardous waste remediation. Desirable attributes include their often sizable areas and isolated locations, controlled access, numerous contamination problems, and increasingly active environmental restoration programs.

EPA headquarters is exploring the use of Federal facilities for both site-specific technology demonstrations and as test locations for evaluation of more widely applicable technologies. Equally important is the establishment of mechanisms to ensure timely sharing of information. *Regions are encouraged to suggest innovative approaches* ***and*** *to be receptive to proposals for innovation from Federal facility managers, e.g., by building timing and performance flexibility into compliance agreements in acknowledgment of current uncertainties associated with innovation.*

The Office of Federal Facilities Enforcement (OFFE) will work with the regions to identify locations for sponsoring potential test and evaluation activities. With assistance from the Technology Innovation Office, OFFE will develop necessary policies and guidance to ensure that support for innovation is congruent with other program and environmental objectives.

7. Joint Technology Assessment Opportunities with Industry under the Federal Technology Transfer Act

During the clean-up planning and implementation process, PRPs or owners/operators should be reminded of the opportunity to engage EPA in evaluation studies and other arrangements at their expense to determine whether innovative technology concepts would be operative in the situation they are facing or other similar situations. Under the Federal Technology Transfer Act (FTTA) of 1986 and Executive Order 12591, cooperative agreements related to research, development, and technology transfer can be expeditiously executed (i.e., in less than 60 days) between industry and government. In this case, such arrangements would allow the PRP to reimburse EPA for facilities, support services, and staff time spent in joint evaluation of early technology treatability or pilot studies. As projects progress into the later planning stages, careful judgement needs to be exercised to avoid new work that will result in unproductive delay, while remaining sensitive to important new technology developments.

Since this program is conducted in the research and development arena, it offers the prospects of non-adversarial engagement, outside the regulatory context, to allow the joint development of credible data about remediation technologies. This opportunity should be especially advantageous to (1) PRPs and owners/operators capable of early planning for technology options at a few sites and desirous of early EPA input, as well as (2) PRPs and owners/operators faced with a number of similar waste sites in the future-- under Superfund, RCRA Corrective Action, and the UST program--who want to develop more uniform, cost-effective technology proposals for such sites. Basic information about the FTTA is described further in Attachment B.

IMPLEMENTATION

The first six initiatives involve field testing new technologies that may benefit by technical assistance from the Office of Research and Development (ORD). ORD represents an objective third party that can be easily accessed through the existing OSWER/ORD support structure. This structure consists of five laboratories, which constitute the Technical Support Centers (both for Superfund and newly established for RCRA), the Superfund Technical Assistance Response Team (START) program, the Bioremediation Field Initiative, and the Superfund Innovative

Technology Evaluation (SITE) program. Several of these programs are discussed later in this memorandum, and Regional offices are encouraged to use them. OSWER has asked ORD to give priority to requests for technical assistance under this directive, and we will use our existing priority-setting systems to accommodate needs articulated pursuant to this directive.

BROADER APPLICATION OF AVAILABLE RESOURCES AND TOOLS

In addition to these new initiatives, the application of other important existing policies and efforts should be broadened.

- Furthering Innovative Remediation at Leaking UST Sites

  State and local UST programs have identified 100,000 confirmed leaks, and this number may triple in the next several years. The majority of sites currently undergoing corrective action are being remediated through pumping and treating ground water and excavation and off-site disposal of contaminated soil. The national UST program has established corrective action streamlining as one of its top priorities. The program's strategy includes promoting the use of improved technologies that will produce better and faster cleanups at lower cost than traditional methods.

  The UST/LUST program has worked closely with the Office of Research and Development and private companies to foster the development of innovative site assessment and cleanup technologies, such as field measurement techniques, soil vapor surveying, vacuum-enhanced free-product recovery, active and passive bioremediation, and vacuum extraction. These technologies now must be moved from demonstrations to routine use in the field. *Regional offices should increase their efforts to make state and local managers and staff, as well as cleanup consultants and contractors, more familiar with these non-traditional but proven technologies. Headquarters will continue fostering the development of even newer tools and techniques and should increase its support of regional efforts to achieve broader use of improved technologies.*

- Further Enabling State Innovative Technology Leadership

  First, *the CERCLA core funding program provides an opportunity to assist states in establishing innovative technology advocates.* Core program cooperative agreements help support state response programs to ensure involvement in CERCLA implementation activities. This may be a vehicle for promoting new technologies where the state and region agree it is appropriate. This approach is currently being utilized with success in Minnesota. The advocates can serve an important role of promoting the development and use of innovative technologies in the state CERCLA programs, with obvious spinoff benefits for their RCRA and UST programs. Some states have shown a strong interest in new technologies, and we should do everything possible to support their efforts and encourage initiatives at the state level.

Second, last year's RCRA Implementation Study highlighted the opportunity to empower a few states interested in furthering technology development. *Regions should be open and encouraging of state applications for authority for RCRA R&D permitting, permit modification, treatability exclusion, and Subpart X permitting.* States not authorized for RD&D permitting may consider a cooperative effort with the region for issuing these permits. The RD&D activities could involve treatability studies for a site or activities to help develop and commercialize a technology. This package of authorities will allow new technology developers and users to flourish in selected states.

In addition to the Federal Facilities Initiative above, states may want to work directly with Federal facilities in developing pilot sites for innovative technology. These activities do not have to be limited to final remedies, but may also include treatability tests, site stabilization, and demonstrations. Federal facilities under both CERCLA and RCRA authority may be particularly well suited for integrating clean-up activities with innovative treatment technologies.

o Model RI/FS Work Plan and PRP Notice Letter Demand for Innovative Options

Some regions have issued special notices containing a Statement of Work and administrative order language requiring the responsible party to evaluate the use of innovative technologies at a particular site. This procedure should receive broader use at Superfund sites where alternatives for remediation are being considered for analysis in the RI/FS and where prerequisite treatability studies are required. This requirement in the special or general notice letters will help facilitate the development and use of innovative treatment technologies by the private sector. Specific language for this approach could be developed from OWPE's guidance document titled "Model Statement of Work for RI/FSs conducted by PRPs" (OSWER Directive 9835.8).

o Advocacy and Funding of Treatability Studies

Superfund program policy (Directive 9380.3-02FS, Treatability Studies Under CERCLA: An Overview, December 1989) requires that treatability studies should be conducted to generate data needed to support the implementation of treatment technologies. For sites where an innovative technology is being considered, these studies will help provide performance information that should assist in the engineering evaluations. Funds are budgeted annually in the SCAP based on expected need for conducting treatability studies. Data and reports from these studies should be forwarded to Glen Shaul at ORD's Risk Reduction Engineering Lab. The appropriate protocol and format for these reports can be found in the "Guide for Conducting Treatability Studies Under CERCLA" (EPA/540/2-89/058). Information contained in these reports will be available through the Alternative Treatment Technology Information Center (ATTIC).

Every effort should be made to conduct or, as appropriate, to evaluate the PRP's treatability study. In planning for this activity, oversight funding should be requested through the SCAP budget process. Oversight of PRP-lead treatability studies may be funded through the enforcement budget. In situations where PRPs recommend use of innovative treatment technologies at a site, but where treatability study data are insufficient, EPA policy allows the Agency to fund and conduct technology-specific treatability studies. The costs associated with the conduct of these treatability studies are recoverable under Section 107 of CERCLA.

o Tracking and Expediting SITE Demonstrations

A recent Inspector General audit of the SITE program focused on delays in matching Superfund sites with technologies. This has contributed to overall delays in completing demonstration projects and technology assessments. In response, *OSWER is encouraging greater participation in the SITE program* and will begin tracking regional site nominations as a reporting measure in STARS (see "Implementation of an OSWER Recommendation from the Office of Inspector General Audit Report on the Superfund Innovative Technology Evaluation (SITE) Program"--memorandum dated January 2, 1991). OSWER will support the designation of additional regional FTE for support of SITE program demonstrations and recognizes the potential for time delays in RI/FSs at sites with demonstration projects. ORD management has also agreed that SITE demonstration projects must be more responsive to regional needs for treatability data.

Recently, ORD completed an internal management review of the SITE program. The purpose of the review was to evaluate the program's impact on Superfund remediation activities and to identify any changes needed to improve the program. Several changes already adopted are directed at making the program a more integral component of regional office Superfund site activities. *The SITE program will make the design of technology evaluations sufficiently flexible to meet the* *regional offices' needs for treatability studies before remedy selection is made*. SITE demonstration data will be presented to the RPM or OSC on a fast turnaround basis so that the data are available to be factored into the remedy selection decision. The SITE program will take advantage of ongoing remediation activities as a source of technology evaluations and technology transfer where possible. In addition, the program will use sites that are being evaluated under the START program and projects that are identified pursuant to this directive, as potential test locations for SITE evaluations.

ATTACHMENT A
Existing Program Efforts to Further Innovative Technologies

OSWER has several other ongoing efforts directed toward furthering the application of innovative alternatives through the acquisition and efficient use of data, reduction of technical uncertainties, and elimination of contracting impediments. These programs represent important resources that should continue to be used. The first two resources, that are of interest to the UST, RCRA, and Superfund Programs, concern the collection and use of data:

o Technical Support and Information Management

Readily accessible information on innovative technologies is a major priority of the Superfund program. This objective is being met through the utilization of on-line computer systems, direct expert technical assistance, and support for field activities to evaluate the performance of a given technology. Currently, EPA maintains several computer databases that may be accessed for information on treatment technologies. These databases include the Alternative Treatment Technology Information Center (ATTIC), the OSWER Bulletin Board (CLU-IN), the ROD Database, the Hazardous Waste Collection Database, and the Computerized On-line Information System (COLIS). These systems include information on the application of innovative technologies and may be used to aid networking among OSCs and RPMs. Due to the general shortage of cost and performance data on new technologies, use of these databases is important to provide the most current information available.

Technical assistance is available to Superfund and RCRA staff through ORD's Technical Support Centers and the Environmental Response Branch, OERR. Part of this effort involves networking among project managers through the engineering and ground water forums. In addition, as part of an initiative to provide direct technical support to OSCs and RPMs, the Superfund Technical Assistance Response Team(START) has been established to help evaluate the potential use of technologies. Currently, technical experts from EPA's Office of Research and Development are providing long-term consultation and support at 35 sites with complex treatment technologies issues. In addition, ORD is assisting the Superfund program in developing protocols for conducting treatability studies, so technologies can be evaluated using standardized parameters. ORD is also providing a staff person in each Regional office to serve as a liaison with their engineers and scientists.

- Bioremediation Field Initiative

  Begun in the 4th quarter of FY 90, this program is intended to provide more real-time information on the field application of biotechnology for treating hazardous waste. Currently, over 131 CERCLA, RCRA, and UST sites have been identified as considering, planning, or operating full-scale biotreatment systems. The major focus of this initiative is to furnish direct support in evaluating full-scale cleanup operations and technical assistance for conducting treatability and pilot-scale studies. Several sites have already been selected for participation in the program. Performance, cost, and reliability information generated from these bioremediation studies will be used to further develop a treatability study database that will be made available to regional staff.

- Procurements for Innovative Technologies

  Over the past several months, OSWER has been working with the Procurement and Contracts Management Division (PCMD) to address particular issues associated with the procurement of innovative technologies. As these issues are resolved, regions are encouraged to use the new provisions to the extent possible. The first issue concerns the *contracting for treatability studies*. Under the Federal Acquisition Regulations (FAR), firms are restricted from performing both the design and construction of a project. *EPA has determined that this prohibition applies only to the prime contractor responsible for the overall design, and not to subcontractors performing treatability studies*. The EPA Acquisition Regulations are being amended to clarify this point and to allow possible exceptions for contractors to work on both design and construction on a case-by-case basis.

  A second issue concerns *constraints on contractors working for both EPA and later working for a potentially responsible party (PRP) at the same site*. This constraint was originally imposed on contractors to avoid conflicts of interest. Innovative technology is a special exception within these general guidelines. Rather than automatically assuming a contractor should first be precluded from working for a PRP after working for EPA, it is EPA's intent and commitment to first permit contractors and/or subcontractors performing evaluations of innovative technologies for the Agency to later work for the PRPs in as many instances as possible. Only in rare instances would EPA envision not permitting such work to be performed for the PRP. EPA and PRPs often work together in the spirit of cooperation and site work may be divided accordingly. *The Agency has therefore determined not to preclude PRPs from using EPA contractors to perform such work as treatability studies*. In addition, we want to ensure that vendors who perform treatability studies for EPA may also remain eligible to support PRP-lead design or construction work. This position is reflected in the final conflict of interest provisions for Superfund contracts which are currently being prepared and were initially published in the Federal Register as a proposed rule.

ATTACHMENT B

United States
Environmental Protection
Agency

Office of Research and
Development
Washington, DC 20460

EPA/600/9-90/050
November 1990

EPA

Opportunities for Cooperative R&D with EPA: The Federal Technology Transfer Act

Both the U.S. Environmental Protection Agency (EPA) and private industry seek new, cost-effective technologies to prevent and control pollution. In the past, however, legal and institutional barriers have prevented government and industry from collaborating in developing and marketing these technologies. Also, the efforts of many companies to develop new technologies have been stymied by a lack of resources, such as scientific experts in particular fields or highly specialized equipment. The Federal Technology Transfer Act of 1986 (FTTA) removes some of these barriers to the development of commercial pollution control technologies.

The FTTA makes possible cooperative research and development agreements (CRDAs) between federal laboratories, industry, and academic institutions. CRDAs set forth the terms of government/industry collaboration to develop and commercialize new technologies. According to the Act, these agreements will foster the technological and industrial innovation that is "central to the economic, environmental, and social well-being of citizens of the United States."

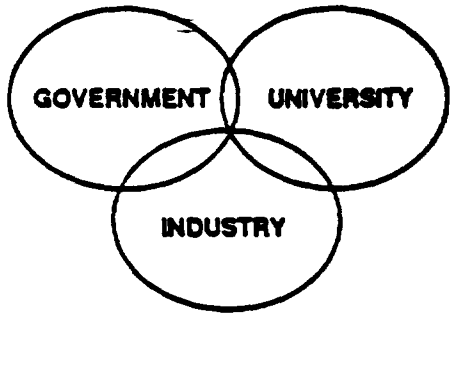
What Can Industry Gain from Signing a CRDA with EPA?

Access to High-Quality Science

EPA's 12 research laboratories employ over 600 scientists and engineers. Many of these laboratories combine world-class expertise with state-of-the-art equipment and fully permitted testing facilities. Certain types of environmental research, such as development of innovative technologies for treating hazardous wastes, require the collaboration of experts in many different fields. This type of interaction is easily adapted at EPA laboratories, because they are inter-disciplinary in nature.

Expanded Communication Channels Between Government and the Private Sector

CRDAs build working relationships between the government and the private sector. All parties benefit from the different perspectives that government and private sector scientists bring to an R&D project.



Exclusive Agreements for Developing New Technologies

Until recently, industry had little incentive to cooperate with federal laboratories because any technologies developed during joint research remained in the public domain for all to use. Now, under some CRDAs, companies are given exclusive rights to market and commercialize new technologies that result from the collaboration.

Licensing and Research Agreements: How Do They Work?

The procedure for setting up a cooperative R&D or licensing agreement under the FTTA is designed to encourage collaboration between industry and EPA laboratories. For industry, the key advantage of the process is the speed and ease with which the agreements can be negotiated and signed. CRDAs are not subject to federal contracting or grant requirements. In addition, each laboratory director has the authority to establish CRDAs for that particular lab, and this decentralization of the decision-making process reduces the administrative procedures involved.

Another important advantage is that CRDAs are flexible enough to fit the goals of many different sizes and types of companies. For example, under the FTTA, a company can support applied research at an EPA laboratory while reserving first rights to involvement in any technology that results. Or, if the scientific mechanism that makes a company's product work is unknown, the company can cooperate with an EPA laboratory to identify this mechanism. A company can also share space and equipment with EPA in a combined effort to develop an innovative technology.

Interested?

Several companies already have CRDAs with EPA, including Exxon, Shell Oil, Ford Motor Company, Dow-Corning, Hewlett-Packard, and CH_2M Hill, as well as several small businesses.

For further information about this program please write to:

Mr. Larry Fradkin, FTTA Coordinator
Office of Technology Transfer and Regulatory Support
Office of Research and Development
U.S. Environmental Protection Agency
26 West Martin Luther King Drive
Cincinnati, OH 45268.